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Variables Affecting the
Use of the Intraosseous Infusion
During Pediatric Resuscitation

by

Sharon L. Hale

A thesis submitted in partial fulfillment
of the requirements for the degree of

Master of Nursing

University of Washington

1996

Approved by Eleanor J Bond
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Jeri Simpson

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Abstract

Variables Affecting the Use of the

Intraosseous Infusion During Pediatric Resuscitation

by Sharon Lynn Hale

Major, United States Air Force

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University of Washington

Intraosseous Infusion (IOI) provides an alternate means of intravascular access during pediatric resuscitation and has been advocated by many professional healthcare organizations. Nonetheless, use of IOI, especially by emergency nurses, appears to be limited. The purpose of this study was to identify variables affecting the use of IOI by emergency nurses during pediatric resuscitation.

A self-administered survey was mailed to a randomized sample of 500 members of the Emergency Nurses Association. The response rate was 48.2% (N=241). The study revealed a widespread awareness of IOI among emergency nurses: 69.2% (N=166) of the respondents had assisted with or performed IOI. Of those nurses who had never used IOI, 55.4% had been trained in the procedure. Only 10.8% of the sample had no IOI training or experience.

IOI use was spread among a range of ages, regions of the U.S. and years of healthcare experience. IOI education was most frequently reported during a Pediatric Advanced Life Support course though subsequent use rates were higher in nurses trained during Inservices. Hands-on practice also increased subsequent use of the procedure. Among institutional factors explored, IOI equipment availability, institutional approval of IOI, and provision of training were reported as influential in IOI use.

Respondents valued IOI for its speed and simplicity of insertion and speculated increased education and training would encourage its use. However, many disliked the invasiveness of IOI, and surmised this was a barrier to use. Other potential barriers included a lack of IOI education and training, as well as a lack of institutional and colleague approval of IOI use. Most respondents opined that IOI was underutilized during pediatric resuscitation.

University of Washington

Abstract

Variables Affecting
the Use of the Intraosseous Infusion
During Pediatric Resuscitation

By Sharon L. Hale

Chairperson of Supervisory Committee: Associate Professor Eleanor Bond
Department of Nursing

The Intraosseous Infusion (IOI) provides an alternate means of intravascular access during pediatric resuscitation and has been advocated by many professional healthcare groups. Nonetheless, use of IOI, especially by emergency nurses, appears to be limited. The purpose of this study was to identify variables affecting the use of IOI by emergency nurses during pediatric resuscitation.

A self-administered survey was developed using a literature review and the investigator's knowledge of IOI. The concepts providing the framework for the survey design were based on a model linking behavioral change (use of IOI) to four variables: the emergency nurse, IOI, education and training, and the institution. The survey was mailed to a national, randomized sample of 500 Registered Nurse members of the Emergency Nurses Association. Response rate was 48.6% (N=243). The study revealed a widespread awareness of IOI among emergency nurses: 68.3% (N=166) of the respondents had assisted with or performed IOI. Of those nurses who had never used IOI, 55.4% had been trained but had not yet had the opportunity to use the procedure. Only 10.8% of the sample had no IOI training or experience.

IOI was most often inserted in the Emergency Department in children five years of age and younger who were in cardiac or respiratory arrest. Most commonly, IOI was used as a venue for intravenous fluid and medication infusions. Use was widespread among professionals for a range of ages, regions of the United States, and years of healthcare experience. IOI education was most frequently reported during a Pediatric Advanced Life Support course. Subsequent use rates were higher in those trained during Inservices. Hands-on practice also increased subsequent use of the procedure.

Among institutional factors explored, IOI equipment availability, institutional approval of the procedure, and provision of training were reported as influential in the use of IOI.

Respondents frequently valued IOI for its speed and simplicity of insertion. They speculated that increased education and training would encourage its use. However, many respondents disliked the invasiveness of the procedure, and surmised this was a barrier to use. Other factors reported as potential barriers included a lack of education and training in the procedure, as well as a lack of institutional and colleague approval of IOI use. The majority of respondents opined that IOI was underutilized during pediatric resuscitation.

Multiple variables affect the use of IOI: attitudes and beliefs of the emergency nurse, characteristics of IOI itself, education and training in the procedure, and institutional policies. Based on these data, it could be predicted that efforts to increase the use of IOI among emergency nurses will require multi-dimensional approaches encompassing these variables.

TABLE OF CONTENTS

List of Figures ..... iii

List of Tables ..... iv

Chapter I: Problem Statement and Purpose ..... 1

Problem Statement ..... 1

Purpose and Specific Aims ..... 2

Chapter II: Review of the Literature ..... 3

Background ..... 3

Historical Perspectives ..... 6

The Intraosseous Infusion ..... 8

Chapter III: Methodology ..... 22

Design ..... 22

Theoretical Framework ..... 22

Sample ..... 25

Instrument ..... 26

Procedures and Protocols ..... 29

Human Subjects ..... 31

Plan for Analysis ..... 32

Chapter IV: Results ..... 34

Introduction ..... 34

Description of the Sample ..... 34

Specific Aim #1 ..... 40

Specific Aim #2 ..... 49

Specific Aim #3 ..... 54

Specific Aim #4 ..... 58

Specific Aim #5 ..... 61

Specific Aim #6 ..... 63

Chapter V: Summary and Recommendations ..... 68

Discussion of Findings ..... 68

Strengths and Limitations ..... 71

TABLE OF CONTENTS, Continued

Implications for Emergency Nursing ..... 73
Implications for Utilization Management/Managed Health Care ..... 75
Recommendations for Further Study ..... 76
List of References ..... 79
Appendix A: Intraosseous Infusion Survey ..... 83
Appendix B: Cover Letter for Survey ..... 88
Appendix C: Letter for Pilot Study Participants ..... 89
Appendix D: Follow-Up Letter ..... 90

LIST OF FIGURES


| Number | | Page |
|---|---|---|
| 1. | Modified Framework Linking Four Variables and Behavior | 23 |
| 2. | Distribution of Experience with IOI | 42 |
| 3. | Rationale for Lack of IOI Participation | 43 |
| 4. | Comparison of reported Time Elapsed Until IOI | 45 |
| 5. | Comparison of Number of IV Attempts Before IOI | 46 |
| 6. | Sources of IOI Training | 57 |
| 7. | Factors Which Encourage Use of the IOI | 62 |
| 8. | Barriers to Use of the IOI | 65 |
| 9. | Adaptation of PRECEDE-PROCEED Model | 77 |

LIST OF TABLES


| Number | | Page |
|---|---|---|
| 1. | Intravenous Access Attempts Versus Patient Age | 5 |
| 2. | Intravascular Access Success Rates | 14 |
| 3. | Demographic Characteristics of the Sample | 35 |
| 4. | Comparisons of Characteristics Related to IOI Use | 48 |
| 5. | Demographics of IOI Non-Users Versus Two Groups of IOI Users | 50 |
| 6. | Education and Training in the IOI | 55 |
| 7. | Institutional IOI Policies | 59 |

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# Chapter I

## Problem Statement and Purpose

### Problem Statement

Resuscitation of the acutely ill or injured pediatric patient can be an emotional and difficult experience for emergency healthcare providers. Establishing vascular access for infusing fluids and medications is a crucial element in pediatric resuscitation, yet anatomical differences such as small, fragile blood vessels and generous subcutaneous fat pose challenges to even the most experienced providers. These challenges are compounded when peripheral veins collapse as a normal compensatory response to shock due to trauma, dehydration, or sepsis (Zimmerman, Coyne, & Logsdon, 1989).

Surgical cutdown and central venous catheterization are frequently attempted when peripheral intravenous (IV) catheterization is unsuccessful. In infants and young children, these routes are considerably more difficult to obtain than in the adult, and greater risks are involved with the procedures. The level of difficulty increases in the pediatric patient with physical or anatomical abnormalities in which traditional landmarks may be inaccurate or inappropriate. Also, these procedures are used infrequently, making it difficult for the emergency healthcare provider to maintain the necessary skills, consequently critical time is lost with multiple unsuccessful attempts at venous access (Parrish, Turkewitz, & Skiendzielewski, 1986).

The intracardiac, sublingual, and endotracheal routes have been used to deliver emergency medications, however, the intracardiac route is hazardous, the sublingual route limits the amount and type of drug that can be administered, and the endotracheal route allows only a few specific medications. None of these routes permits fluid or

blood replacement, so they are of limited value in pediatric resuscitations where volume is required (Neal & McKinley, 1994).

As quick access to the central circulation may improve pediatric resuscitation outcome, the guidelines outlined in the Pediatric Advanced Life Support (PALS) textbook (Chameides, 1994) recognize intraosseous infusion (IOI) as an effective alternate route for the administration of emergency fluids and medications. The procedure has been endorsed and taught in PALS courses for use in emergency situations when venous access cannot be established in three attempts or within 90 seconds, whichever comes first. These guidelines emphasize the use of IOI when fluid and medication management is crucial to advanced life support in children under six years of age (Wheeler, 1989).

## Purpose and Specific Aims

Despite widespread endorsement of the procedure, little is known about the actual use of IOI in clinical practice. Thus, the purpose of this study is to identify variables that affect the use of IOI during pediatric resuscitation. The specific aims of this study are to determine the following in a representative sample of emergency nursing RNs:

1. the extent to which IOI is currently being utilized during pediatric resuscitations,
2. the demographics of nurses who do and do not use IOI,
3. IOI technique education and training,
4. the institutional policies that guide practice,
5. factors that encourage the use of IOI, and
6. potential barriers to the use of IOI.

# Chapter II

## Review of the Literature

### Background

Successful resuscitation of pediatric patients often hinges on quick intravascular access for fluid and volume management. According to Schoenfeld and Baker (1993), pediatric cardiopulmonary and trauma resuscitations frequently lead to favorable outcomes in respiratory arrests and traumatic injuries. Rosetti, Thompson, Aprahamian, Darin, and Mateer (1984) found that successful pediatric resuscitations had intravascular access established significantly sooner than those with poor outcomes or increased mortality. In a three year retrospective study of 66 pediatric cardiac arrests, they examined the times from the onset of the arrest to the establishment of intravascular access. These times were analyzed in the context of patient age and outcome. In more than six percent of the patients, intravascular access was never obtained. Children under two years of age had significantly prolonged times to intravascular placement ($P<0.05$) when compared to older children.

Rosetti et al (1984) have documented the difficulty in obtaining vascular access in children, especially those under two years of age. Losek, Hennes, Glaeser, Hendley, and Nelson (1987) conducted a retrospective chart review of 114 pulseless, nonbreathing pediatric patients (less than 18 years of age) receiving on-going resuscitation at the time of arrival to the emergency department (ED) to determine the performance of life-saving procedures by prehospital personnel. Venous access was established in 36 (32%) of the patients prior to arrival in the ED. Of these 36 patients, venous access was established in 13 (19%) children 0 to 17 months of age, 10 (48%) children 18 months to 12 years of

age, and 13 (72%) children greater than 12 years of age. There was a significant trend to increasing establishment of vascular access with age ($P<0.01$) with nearly 100% establishment rates in adults.

Tsai and Kallsen (1987) compared IV access attempts with patient age in 442 pediatric patients (newborn to 18 years of age) who received treatment by a prehospital advanced life support unit for a medical or trauma emergency. They found significant ($P<0.001$ by Z score) differences in both the incidence and success rates of IV access when adolescents were compared with younger age groups (Table 1). Attempts at IV access were related to prolonged on-scene times and low success rates in children less than six years of age, leading the investigators to question whether attempts at IV access are of value in the prehospital arena. They argued that efforts should be directed towards alternate routes of fluid and medication administration in younger (less than six years of age) children.

Unlike adults, children rarely experience cardiopulmonary arrest as a primary event. Rather, the arrest is usually the result of a progressive deterioration in respiratory and circulatory function secondary to non-cardiac causes such as hypoxia, sepsis, and trauma. Because the survival rate of infants and young children in cardiopulmonary arrest is poor, it is essential that the emergency healthcare provider recognize the signs and symptoms of respiratory failure or shock and quickly initiate respiratory and circulatory support. IOI is a safe and rapid method of achieving intravascular access for the resuscitation of the critically ill or injured child. In the event of vascular collapse, the non-collapsible bone marrow provides an optimal site for the administration of fluids and

TABLE 1. Intravenous Access Attempts Versus Patient Age (Tsai & Kallsen, 1987)

| | **Neonate N=0 (0-1mos.)** | **Infant N=7 (2-11 mos.)** | **PreSchooler N=29 (12 mos.-6 yrs.)** | **Child N=58 (7-12yrs.)** | **Adolescent N=348 (13-18yrs.)** |
|---|---|---|---|---|---|
| IV Ordered, Not Attempted (%) | 0 | 0 | 3.5 | 3.5 | 2.3 |
| IV Attempted, Failed (%) | 0 | 71.4 | 31.0 | 12.1 | 5.5 |
| IV Attempted, Successful (%) | 0 | 28.6 | 65.5 | 84.5 | 92.2 |

medications (Wheeler, 1989).

To decrease the morbidity and mortality of critically ill or injured children, emergency nurses must be knowledgeable of appropriate interventions for children requiring emergency care (Haley & Baker, 1993). There is limited documentation of the use of IOI in pediatric resuscitation, and conflicting opinions are noted. Sawyer, Bodai, Blaisdell, and McCourt (1994) note that the use of IOI for intravascular access during pediatric resuscitation is increasing and shows great promise, whereas Rieger, Berman, and Striebel (1994) assert that the popularity of IOI is still more theoretical than practical; and that in spite of wide discussion, it is not frequently practiced.

The actual utilization of this procedure by emergency nurses, both prehospital and in the ED, is unknown. Further, little information is available regarding why IOI is or is not used. This study will help elucidate how much and where the technique is being used and by whom, and what barriers may be operating against its use. With this knowledge base, programs that will optimize behavioral change and the increased use of the IOI technique by emergency nurses can be planned.

## Historical Perspectives

Alternate means of establishing vascular access during pediatric resuscitation can be useful and potentially lifesaving; IOI is one such route. The concept of using bone marrow for administration of fluid is well anchored in history. As early as the 1920s, Drinker, Drinker, and Lund (1922) described the anatomy of bone marrow and its adequacy for infusion of fluids in mammals. Tocantins (1940) first described IOI as a clinical technique, noting that substances injected into the bone marrow cavity were

rapidly taken up into the general circulation with physiologic responses similar in intensity to those substances injected via the peripheral intravenous (IV) route. In a series of well controlled experiments, Tocantins (1940) transfused exsanguinated rabbits through the tibia, corrected hypoglycemic seizures with a dextrose solution, and noted the appearance of Congo red dye in the heart within ten seconds after tibial infusion.

In 1944, Reisman and Tainsky described the IOI technique in detail, advocating its use in the proximal tibia or distal femur in infants and children. Elston, James, Kaump, and Irwin (1947) reviewed 112 bone marrow infusions in 40 infants. Of the 112 attempts at establishing an IOI, 97 were successful on the first attempt. They described the IO route as "not only a constant but a safe portal of entry in the medullary cavities of the long bones of the legs" (Elston, James, Kaump, & Irwin, 1947, p. 143). In Europe, Heinild, Sondergaard, and Tudvad (1947) reported that of 982 IOIs given to 495 pediatric patients, all but 18 of the infusions were successful. These early advocates of IOI intended it as a supplement under certain conditions such as cardiac arrest, shock, seizures, or burns when the IV route was undesirable or the veins unavailable. The early use of IOI primarily involved blood transfusions, but glucose solutions were also infused.

The IOI remained popular through the 1950s, with increased refinement in the technique as well as in equipment such as bone marrow needles. However, during the later 1950s and throughout the 1960s, other routes of intravascular access were considered. New techniques using the endotracheal, intracardiac, intraperitoneal, and sublingual routes became popular, and the use of plastic and polyfluoroethylene venous

catheters facilitated maintenance of IV infusions (Sawyer, Bodai, & Blaisdell, 1994). With these improvements in techniques and equipment, IOI was essentially abandoned. For the next 20 years, few healthcare providers were trained in the IOI technique. However, with the introduction of cardiopulmonary resuscitation and the increased interest in pediatric emergency medicine, more emphasis on resuscitation and alternate routes of vascular access led to a renewed interest in this all but forgotten technique (Jaimovich & Kecskes, 1991).

## The Intraosseous Infusion

### Anatomy and Physiology

IOI uses the extensive vascular network of the long bones to reach the systemic circulation. Infused substances enter the venous sinusoids within the medullary cavity, drain into central venous channels, and exit the bone via the nutrient or emissary veins. The use of the marrow of the long bones as a route for infusion is usually limited to children under six years of age as the red marrow is physiologically replaced by less vascular yellow marrow at approximately that age (Evans, McCabe, & Thomas, 1994).

The IOI insertion and infusion technique is simple and has changed little since the studies of the 1940s. The anteromedial surface of the proximal tibia is the preferred site of insertion as this area has easily recognizable and palpable landmarks and is free from any significant musculature or neurovascular structures. The tibial tuberosity is palpated, and the needle is inserted one to two fingerbreadths (one to two centimeters) distally to avoid damage to the epiphyseal growth plate (Evans, McCabe, & Thomas, 1994). The distal tibia and distal femur may also be used as IOI sites. A major advantage of these

sites is that airway management and chest compressions are not interrupted during IO insertion.

Method and Technique

Once the site of IOI placement has been decided, the patient's leg is immobilized and a small sandbag placed behind the knee for support. The site is prepared as if for an IV insertion and a local anesthetic used if the patient is conscious. Any needle sturdy enough to penetrate the bony cortex can be used, though specially designed IO or bone marrow needles are available. Short shaft needles with a handle for operator comfort allow for premeasured insertion depth, and an inner stylet is critical for preventing bone plugs from occluding the needle lumen (Neal & McKinley, 1994).

Contraindications

Because the IOI is recommended only in life-threatening emergencies where vascular access is critical, few contraindications exist. Needle placement through an area of cellulitis or an infected burn increases the risk of infection and should be avoided (Evans, McCabe, & Thomas, 1994). Recently fractured bones should not be used due to the risk of subcutaneous extravasation. Two conditions are consistently cited as absolute contraindications for IOI. Osteogenesis imperfecta is a congenital bone disease that causes bones to fracture easily, while osteopetrosis is an excess calcification of the bones that causes spontaneous fractures. According to Evans, McCabe, and Thomas (1994) use of IOI in these conditions could increase the risk of iatrogenic fractures.

Complications

As with any invasive procedure, complications may occur with IOI. Jaimovich and

Kecskes (1991) report inability to enter the marrow cavity as the most common problem; either the cavity is not penetrated or the needle is accidentally forced through the opposite side of the bone. Subperiosteal infusion can occur if the needle is not properly placed within the marrow. Placing two puncture sites in close proximity could cause fluid infused through one site to leak out the other site. Subcutaneous edema secondary to leakage around the needle can also occur.

According to Fiser (1990) complications such as localized cellulitis and formation of subcutaneous abscesses have been reported to occur in 0.7% of IOIs. This is less than the incidence of local infection associated with indwelling IV catheters (3.7%) and may be related to the shorter duration of IO catheter placement. However, serious complications are rare. Rosetti, Thompson, Miller, Mateer, and Aprahamian (1985) reviewed 30 major IOI studies conducted from 1942 through 1977. Of 4270 IOIs, osteomyelitis occurred in only 0.7%, and usually only if the infusion remained in place for a prolonged time or was placed in a septic patient. Wright, Reynolds, and Nachtsheim (1994) reported a case of compartment syndrome in an 11 month old child whose IOI remained in place over 53 hours.

A small cortical defect which resolves spontaneously can be seen on X-Ray after the IOI is discontinued; however, fractures caused by IOI are rare. Katz and Wojtowycz (1994) suggest that most complications can be prevented if sterile technique is used, infected or fractured long bones are avoided, only one insertion per long bone is attempted, and IOI is maintained only until other intravascular access can be obtained.

Effectiveness

To be of the greatest use as an emergency alternate to IV access, intraosseous infusion of fluids and medications should be comparable in effect to IV infusion. Tocantins (1940) discovered that fluids injected into the bone marrow of experimental animals entered the systemic circulation at a rapid rate. More recent investigations have examined the effectiveness of the IOI for delivery of specific substances to the central circulation.

Cameron, Fontanarosa, and Passalaqua (1989) directly examined peripheral to central circulation delivery times using a radioisotope tracer and compared the IO to peripheral IV routes during normovolemia and hypovolemia in a canine model. Eight dogs with a mean weight of 17.5 kilograms were randomly assigned to either the IV or IO groups and received technetium in a saline bolus injected by either by IV or the IO route. The normovolemic phase of the study showed no significant difference in central delivery times between the two groups. The mean transit times to central circulation were 9.96 (+/- 2.15) seconds and 9.93 (+/- 1.53) seconds, respectively. The animals in both groups were then bled to approximately 35% of their estimated blood volume to simulate a hypovolemic state. Although the time to central circulation was longer in the IO group, 12.79 (+/- 4.42) seconds, than in the IV group, 9.07 (+/- 1.72) seconds, the difference was not statistically significant. The findings in this study suggest that the IO route is an effective method of delivery for fluids and medications in both normally hydrated and volume-depleted states.

Several potential limitations to the Cameron, Fontanarosa, and Passalaqua (1989)

study were noted. First, there was a difference in the mean weights of the two groups of dogs, thus the authors determined the transit times adjusted for weight. Second, although the dogs were hypovolemic, they were not hypotensive as measured by femoral arterial line pressures. Because hypotension can change the dynamics of blood flow, the study's findings would not be generalizable to hypotensive states. A third limitation was the small sample size of only eight dogs. Future studies could eliminate weight as a confounding factor between the IV and IO groups by utilizing both methods of infusion in each animal and then comparing transit times. Despite these limitations, the findings support the use of IOI as an alternate route for rapid delivery of substances to the central circulation.

Orlowski, Porembka, Gallagher, Lochrem, and VanLente (1990) compared the pharmacokinetics of emergency fluids and medications administered by the IO, central venous, and peripheral venous (IV) routes. Twenty-one dogs weighing 18.4 to 26.8 kilograms were studied, each with a bone marrow needle in the distal femur, an IV catheter in the femoral vein, and an IV catheter in the peripheral forepaw vein. Each of six solutions and medications was administered by each of the routes in a randomized sequence. The drug effect or level was allowed to return to baseline before administration by a different route. The IO route of administration was found to be comparable with the central and peripheral IV routes for all emergency solutions and medications studied, with equivalent magnitudes of peak effect or drug level and equal or longer duration of action. By using a larger sample (N=21 dogs) and obtaining both IO and IV access in each animal, the investigators were able to overcome the limitations

noted in the Cameron et al (1989) study and validate the findings of that investigation. However, neither study addressed the age of the dogs nor how bone marrow maturation may affect the results of the studies.

Access Times

Four common methods of establishing intravascular access during pediatric resuscitation are percutaneous peripheral IV catheterization, central vein catheterization, surgical venous cutdown and IOI. Noting that relatively few studies had systematically reviewed their efficacy, Brunette and Fischer (1988) compared the four standard methods in 33 pediatric patients (average age of five months) who experienced cardiac arrest. Percutaneous peripheral IV catheterization, central venous catheterization, surgical venous cutdown, and IO access were retrospectively evaluated for (a) speed of placement, (b) success rate, and (c) time intervals between patient arrival in the ED and the establishment of each type of access (Table 2). The techniques of surgical cutdown and central line placement, though comparable in success rate to the IO route, took significantly longer for placement than the IO route. The percutaneous peripheral IV route was the quickest under ideal conditions (i.e. when successful) but the authors cautioned that attempts at peripheral IV access should be brief with rapid progression to the IO route if attempts to insert a peripheral IV were unsuccessful.

Several limitations to this study were noted. The authors did not present a definition of "success," thus the reader must assume that successful access means the ability to infuse fluids and medications. Also, only children presenting in cardiac arrest were included in the study and none of these children survived to hospital discharge. The

TABLE 2. Intravascular Access Success Rates (From Brunette and Fischer, 1988)

| | **Percutaneous Peripheral** | **Central Venous** | **Surgical Cutdown** | **Intraosseus Infusion** |
|---|---|---|---|---|
| Attempted; N | 17 | 30 | 16 | 12 |
| Successful Access Achieved; N (%) | 3 (18%) | 22 (73%) | 13 (81%) | 10 (83%) |
| Mean Time (SD); in Minutes to Achieve Access | 3.0 (2.0) | 8.4 (3.3) | 12.7 (3.2) | 4.7 (1.5) |

authors conceded that children under four years of age arriving to the ED in cardiac arrest despite prehospital emergency care have a poor prognosis regardless of treatment, thus it would be difficult to draw conclusions regarding the optimal method of obtaining intravascular access in such patients. Further investigations are warranted in order to evaluate clinical conditions such as hypovolemia or shock, in which intravascular access and volume replacement would play an important role in successful resuscitation.

Ease of Access

Several investigations have evaluated the simplicity or ease of access of IOI. Smith, Keseg, Manley, and Standeford (1988) reviewed the medical records of pediatric patients (N=13) in whom IOI was attempted prior to ED arrival. IOIs were successful in 12 of the 15 attempts (80%). All successful cases required only one attempt to establish IO access and all needles were placed in less than 30 seconds. In addition, the authors investigated the emergency healthcare provider's perceptions of the level of difficulty of the IO insertion. Eleven paramedics who had performed IO insertions were asked to grade the level of difficulty of the insertion on a scale of one through ten. Ten paramedics evaluated the level of difficulty as "one," the easiest, with the remaining paramedic evaluating the level of difficulty as "two." It would have been useful for the authors to have defined "easiest," perhaps in comparison with peripheral IV access or other paramedic skills. The addition of comments identifying why IOI was perceived as easy would also have helped to illustrate the simplicity of the route.

Fuchs, LaCovey, and Paris (1991) compared the establishment of a simulated IOI in three different prehospital settings: classroom (simulating the scene), a medic unit

traveling 25 miles per hour and making slow, steady turns, and a medic unit traveling 30 miles per hours with sudden stops and starts. The purpose of the study was to determine the time to establish an IOI and the success rate at the scene and enroute to the ED. Study participants (N=12) included eight paramedics and four emergency medicine residents. Detached chicken legs were used to simulate the legs of infants and young children, and detached turkey legs to simulate the legs of older children. The procedure was timed from skin entry of establishment of the infusion, and the time for establishment of the infusion was defined as the sum of the time intervals required for unsuccessful and successful attempts. Successful placement of the IO needle was confirmed by the aspiration of marrow or the free flow of five to ten milliliters of normal saline without extravasation into the surrounding tissues. All 12 participants were successful in establishing an IOI in all three scenarios. Seventy-five percent of the participants in the classroom (scene) scenario, 50% of the participants in the turn scenario, and 58.3% of the participants in the stop and go scenario were successful on the first attempt (P=NS). Median times to success were 27.6 seconds in the scene scenario, 29.9 seconds in the turn scenario, and 30.3 seconds in the stop and go scenario (P=NS).

The authors conceded that such scenarios may not be valid simulations of the stressful environment of a child in cardiac arrest; however, the element of artificiality would be present in any procedure simulated in a classroom environment. The study did demonstrate that times to successful placement in all three scenarios were comparable, thus highlighting IOI as an ideal technique to use at the scene or enroute to the ED.

Proficiency

Healthcare providers can quickly become proficient in the IO technique. Most providers require three to four hours of training that incorporates lectures, audio-visual aids, and laboratory use of IOI manikins or chicken or turkey leg bones. Several nationally recognized courses such as PALS, the Emergency Nurse Pediatric Course (ENPC) and Advanced Trauma Life Support (ATLS) currently include practical training. Through this training, healthcare providers generally can gain IO access in 30 to 60 seconds, with first attempt success rates of 85 to 95% (Neal and McKinley, 1994).

A study by Glaeser, Hellmich, Szewczuga, Losek, and Smith (1993) questioned the emergency healthcare provider's ability to maintain proficiency in the IOI technique. In a descriptive, non-randomized trial, 144 Emergency Medical Technician-Paramedics (EMT-P) from 11 separate medic units were taught the IOI technique. All patient records generated over the next five years were reviewed to identify patients receiving attempts at IOI. A total of 152 patients received 165 attempts at IOI, with 115 (76%) having successful placement. Success rates of individual years were not significantly different during the five year period. The authors note that IOI is used relatively infrequently compared with other EMT-P skills; a comparison of the numbers of peripheral IV insertions performed during the five year study period would have been useful in illustrating the difference in use. However, the objective of the study was to evaluate whether the EMT-Ps would retain their IO skill proficiency over a period of time. The study results suggest that proficiency is maintained over time despite infrequent use of the skill.

Recommendations for Use

Although it is rare that some method of intravascular access is absolutely unobtainable in a pediatric patient, minutes and sometimes hours are lost as futile attempts are made to cannulate poorly accessible veins whether from small patient size, obese, edematous, or burned extremities, peripheral vascular collapse, or cardiac arrest (Parrish, Turkewitz, & Skiendzielewski, 1986). Reviews of the literature indicate that IOI is an effective, safe, and rapid alternate route of intravascular access. The technique requires little time or experience in which to acquire proficiency, and proficiency can be maintained during periods of infrequent use. The technique has definite anatomic landmarks, lending itself to easy instruction, and has a low complication rate, optimizing risk versus benefit concerns. Patient survival is improved with immediate intravascular access, which can be achieved simply and effectively via IOI. This procedure enhances the emergency healthcare provider's ability to resuscitate unstable pediatric patients who in the past may have succumbed to their illness or injury without the benefit of intravascular access (Siegler, Tecklenburg, & Shealy, 1989).

Schoenfeld and Baker (1993) identified the most commonly used procedures in a pediatric ED. The ED records of 183 children treated in the cardiopulmonary and trauma resuscitation room were reviewed for various data, including the utilization of resuscitation skills such as IOI. Although intravascular access was most commonly obtained by peripheral venous catheterization (74.9%), IOI was used in 24% of the patients studied. Emergency healthcare providers in hospitals other than pediatric or tertiary referral centers may have less experience with pediatric resuscitations.

According to Manley, Haley, and Dick (1988), 90% of pediatric visits are to the EDs of general or community hospitals. Thus, they suggest that every ED should have personnel with the ability to initiate an IOI. The authors also suggest that IOI should be thought of early on in a pediatric resuscitation, and should follow two quick, unsuccessful attempts at peripheral IV catheterization.

Revised guidelines in the PALS textbook (Chameides, 1994) recommend the use of a protocol for establishment of vascular access during pediatric resuscitation. Such a protocol would limit the time devoted to attempts at peripheral and central venous catheterization, favoring other techniques with a higher likelihood of success. In children under six years of age, IO access should be established if reliable peripheral IV access can not be achieved within three attempts or 90 seconds, whichever comes first. Although not recommended as a replacement of conventional IV access, IOI has definite utility in pediatric resuscitation.

Barriers to Use

Despite the available base of clinical literature on the use of IOI during pediatric resuscitation, the documentation of its effectiveness and simplicity, and its endorsement by professional organizations, the extent to which the technique has been adopted and is actually used on a national level by emergency healthcare providers is not clearly documented. The available literature generally discusses the activities of a single ED, EMS unit, or limited geographic community (Salassi-Scotter & Fiser, 1990).

Zimmerman, Coyne, and Logsdon (1989) subjectively observed that IOI was underutilized in the prehospital setting. Program representatives from 133 of the 155

known North American aeromedical transport programs were surveyed to determine their implementation of IOI. Nearly 87% of the programs had never utilized IOI and were not considering its use, 15.8% had received an Inservice on the technique but had not yet used it, and 1.5% were considering its use. Only 13.5% of the programs had actually implemented the technique. Of those programs which used IOI, 53.9% considered use of IOI a "last resort," and only one program noted that IOI was their method of choice for vascular access during pediatric resuscitation. The authors saw this underutilization as paradoxical given the high rate of successful insertions and low complication rate seen with IOI. They reported that programs with experience in the technique appeared more aggressive in its early implementation.

This study illustrates the use of IOI in a limited sample, and only theorizes as to why it is underutilized. The authors suggest the most prominent reason for the lack of use of IOI is its unfamiliarity with many healthcare providers, despite its resurgence in popularity. While none of the program representatives surveyed objected to IOI, most were simply unaware of the technique or its availability. Wagner and McCabe (1988) assert that a lack of familiarity with IOI may lead healthcare providers to regard it with suspicion, and deem it unnecessary, difficult to perform, or even dangerous.

Strategies

The lack of documentation regarding the use of IOI indicates a need for determination of the extent of actual use by emergency nurses nationally, and identification of variables affecting its use. Identification of positive variables can be used to enhance adoption of IOI through increased use of successful training

approaches, development of standards/protocols, and consistent quality assurance activities for monitoring the effectiveness of the procedure. Variables negatively affecting use must also be identified so that strategies to overcome these barriers can be designed and implemented. These strategies could then be used to foster dissemination of accurate and consistent information regarding IOI on a broader scale to all emergency healthcare providers who participate, or could potentially participate, in pediatric resuscitation (Salassi-Scotter & Fiser, 1990).

# Chapter III

# Methodology

## Design

It is not known to what extent IOI is used by emergency nurses during pediatric resuscitation. Descriptive designs are used to depict the prevalence of a problem; their purpose is to observe, describe, and document aspects of a situation as it occurs naturally (Polit & Hungler, 1991). Thus, a descriptive survey (Appendix A) was developed. This design was chosen in order to impose a minimum of structure so that relevant information regarding the emergency nurse's thoughts, feelings, and beliefs regarding the IOI could be studied. Positive features of a mail survey design include: (a) its directness and versatility in gathering information, (b) the ability to gather retrospective data regarding activities and events occurring in the past, (c) the ability to obtain a larger and more geographically diverse sample given a limited amount of time and funds, and (d) complete anonymity for the participants (Polit & Hungler, 1991).

## Theoretical Framework

The concepts providing the framework for the survey design are based on Cervero's (1985) model of behavioral change and variables influencing this change. Cervero surmised that behavior (use of IOI) is the result of interactions between four generic classes of variables: the individual (emergency nurse), the procedure (IOI), the education and training in the procedure, and the environment (institution) in which the emergency nurses practices (Figure 1). The theoretical rationale for the development of the survey incorporates these four variables and explores their resulting interactions to identify the context in which clinical decisions regarding IOIs are made.

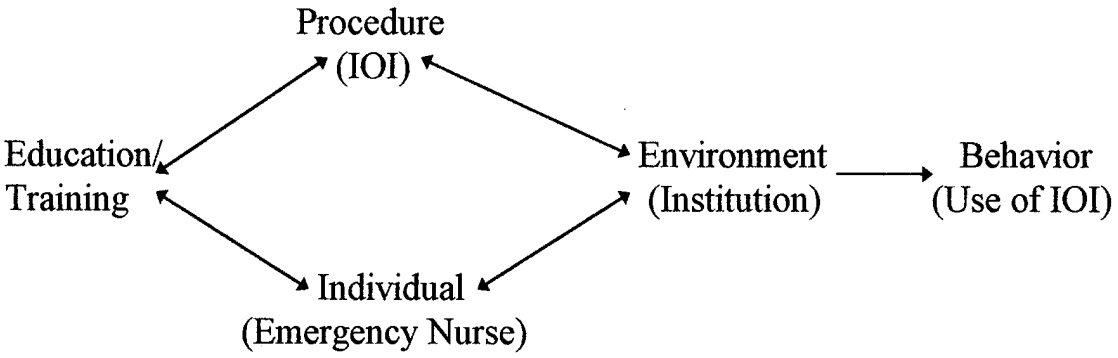


FIGURE 1. Modified Framework Linking Four Variables and Behavior (Use of Intraosseous Infusion [IOI]).

Characteristics of the procedure will affect whether it is used in clinical practice and under what circumstances. Kanouse and Jacoby (1988) list several questions regarding a procedure which can be asked to identify its advantages and disadvantages. Does the procedure improve quality of patient care? Do defined actions need to be taken in defined circumstances for a specific group of patients? Perceived attributes of the procedure can also affect its use. Is the procedure perceived as more effective or simple to use and understand than other procedures? To what degree are the results of the procedure visible to others? Are the results positive? All things being equal, it would seem that a procedure that is simple yet produces dramatic results would be adopted more readily than complex procedures or ones with questionable results (Kanouse & Jacoby, 1988).

Programs aimed at transferring information regarding a procedure serve many goals: (a) eliminating gaps in existing knowledge or skills, (b) facilitating informed decision-making, (c) changing practice behavior in a positive direction, and (d) improving quality of care delivered to the patient (Kanouse & Jacoby, 1988). An important factor in education and training is to determine which information transfer/education setting is most likely to elicit positive use of the procedure.

It is also useful to know how emergency nurses feel about a particular clinical approach to treating a specific type of patient. Is the procedure compatible and consistent with the emergency nurse's existing beliefs, attitudes, past experiences and current methods of practice? A belief that patients are not currently experiencing satisfactory outcomes will motivate the emergency nurse to incorporate new ideas or

skills; likewise, if the emergency nurse believes an approach or procedure has served them well, they will not be motivated to try another. All other variables will not induce change in an individual who is not motivated to change (Cervero, 1985).

Emergency nurses are less likely to use procedures that require facilities or resources not under their control, or that may lead to outcomes they feel they are unprepared to handle. Decisions regarding clinical practice can be made (or constrained) at the institutional level, thus it is important to understand the environment in which emergency nurses make the clinical decision to use a procedure (Kanouse & Jacoby, 1988). Are resources and equipment available to the emergency nurse? Are protocols or standards available to guide the emergency nurse's decisions? The interactions between these variables are complex and any or all can influence whether IOI is used or not used.

## Sample

Surveys were mailed to a random sample of emergency nurses who participate, or could potentially participate in, pediatric resuscitations. The emergency nurses' names and addresses were obtained from a randomized, computer generated mailing list purchased from the Emergency Nurses Association (ENA). A total of 500 surveys were distributed. This sample was based on the constraints of time and the financial resources of the primary investigator and represented 2.5% of the ENA's total active membership. Participants included emergency nurses employed as staff nurses, nurse managers/administrators, advanced practice nurses, or nurse educators/researchers in the ED, and flight nurses employed in the prehospital setting. Study inclusion was based on

active membership in the ENA as evidenced by inclusion on the organization's mailing list, and an United States address.

According to Dillman (1978), response rates to mailed surveys are variable, with a response rate of 50% considered acceptable. However, factors such as the length and appearance of the survey, personalization of the correspondence, and guarantee of confidentiality can influence response rate and can be manipulated in order to increase participation. Another factor influencing survey response rate is utilizing a specialized population; it was anticipated that a five page survey sent to a specialized population such as emergency nurses would yield at least a 50% response rate.

## Instrument

Development of the survey (instrument) was guided by Cervero's (1985) framework. Main sections of the survey were based on the four variables linking behavioral change, and included assessments of the emergency nurse (demographic information), their actual use of IOI (use of IOI), their education and training in IOI (training) and the environment in which they practice (institutional policy). The survey was five pages in length and included 24 questions. According to Dillman (1978), survey questions can be classified as requesting one or more types of information: (a) who people are or their attributes (demographic information), (b) what people do or their behavior (use of IOI), (c) what people think is true or their beliefs (personal experiences and opinions), and (d) what people say they want or their attitudes (additional comments). Combinations of closed and open ended questions were included to obtain this information.

Closed ended questions required the participant to choose from among discrete, unordered categories by independently evaluating each choice and selecting one that best reflected his or her situation. Category options were based on reviews of the literature (Brunette & Fischer, 1988: Chameides, 1994; Evans, McCabe, & Thomas, 1994; Fiser, 1990; Fuchs, LaCovey, & Paris, 1991; Manley, Haley, & Dick, 1989; Miccolo, 1990; Salassi-Scotter & Fiser, 1990; Sawyer, Bodai, Blaisdell, & McCourt, 1994; Smith, Keseg, Manley, & Standeford, 1988; and Zimmerman, Coyne, & Logsdon, 1989), and the primary investigator's clinical knowledge of the IOI. An "other" option was included with each of the closed ended questions as it was not possible to list every possible response option. Several open ended questions were employed as the primary investigator could not anticipate the various ways in which participants were likely to have responded to questions. Open ended questions were used to stimulate free thought, solicit suggestions, probe participant memories, and clarify positions. Further, they allowed the participant to vent frustrations and state strong opinions (Dillman, 1978).

Demographics characteristics of the survey sample were obtained through the collection of background data. According to Polit and Hungler (1991), personal characteristics such as age, gender, and employment status have been shown to be related to a person's behavior and attitudes. These data also allowed a comparison of the survey population with the sample population. Non-threatening demographic questions were placed at the beginning of the survey, with increasing levels of self-disclosure towards the end. The back cover (page five) of the survey consisted of an invitation to make additional comments, a thank you, and plenty of "white space." The

request for any additional comments on the topic of the study sought to overcome a frequent objection of surveys: questions written in ways that did not allow the participants to fully express their experiences. Also, the solicitation of comments was based on an exchange principle, where the participants were rewarded by being asked their advice in a consulting manner (Dillman, 1978).

A cover letter (Appendix B) was attached to each survey. This letter introduced the survey and the researcher to the participant, identified the study's purpose, and presented the need for the study. According to Dillman (1978), in order to establish the importance of the study, it must be described as being useful to some group with which the participant identifies, and rests on the assumption that doing something useful will be rewarding to the participant. The cover letter also promised anonymity, as well as offered the participant a copy of a summary of the study results. This offer was an explicit attempt to reward the participant in a manner consistent with something they found interesting.

Content validity of the survey was established by conducting reviews of the literature to determine behaviors representative of emergency nurses' use of IOI. Validity was pre-tested in two ways. Initial testing was accomplished by using an expert panel to critically review the survey and provide comments and concerns regarding clarity, research adequacy, and freedom from bias. The expert panel consisted of five reviewers: two University of Washington faculty with expertise in the use of surveys, and three emergency nurses. The panel members were selected based on current ED experiences so as to be representative of the sample which would ultimately be surveyed.

A copy of the survey and cover letter was given to each member of the panel for review.

A pilot study of the instrument was conducted to identify potential flaws in instrumentation or methods. The pilot study was designed to test the overall survey, as well as the individual questions, thus emergency nurses who had used or had knowledge of IOI were specifically selected. Clarity and interobserver variability of the survey was assessed by asking ten emergency nurses to answer the survey questions independently. The pilot study participants were briefed by the primary investigator on the study's purpose and content. The participants were then asked to evaluate the clarity of the questions and their congruence with the overall purpose of the study, to suggest possible revisions to the survey by addition or subtraction of specific questions, and to comment on the physical appearance of the survey. Written instructions were presented in a Letter for Pilot Study Participants (Appendix C) and were attached to the survey. Eight of ten (80%) pilot study participants completed and returned the surveys.

## Procedures and Protocols

Following approval by the University of Washington School of Nursing and the National Emergency Nurses Association (ENA) Standing Committee on Research, a random, computer generated mailing list consisting of 500 active members' names and addresses was obtained (purchased) from the ENA.

### Information to Participants

Information was provided to all participants through the cover letter attached to each survey. A brief overview of the study and its purpose, as well as survey instructions were included. An additional reviewer cover letter was given to pilot study

participants. Anonymity of each participant was guaranteed. The participant was given the opportunity to provide his or her name and address on an index card included with each survey in order to receive a copy of a summary of the study results. The survey and index card were separated by a disinterested volunteer immediately upon receipt of the completed survey.

Participant Tasks

Each participant was encouraged to complete the survey in its entirety and was requested to return the survey in the pre-stamped and addressed envelope provided with each survey. Each participant was encouraged to include additional comments and concerns regarding IOI on the last page of the survey. It was noted that the survey would take the participant approximately 10 to 15 minutes to complete.

Data Collection Steps

The pilot study consisted of ten ENA members who responded to a letter to the editor published in the February 1995 issue of the Journal of Emergency Nursing. The letter, submitted by the primary investigator, invited ENA members to correspond with the primary investigator and share their experiences with IOI. Pilot study participants were mailed a survey with an enclosed stamped and pre-addressed envelope and were requested to complete and return the survey within one week of receipt. Although a 100% return rate of the pilot study surveys was desired, an 80% return rate was obtained. Pilot study surveys were not included in the main study. Information regarding the study purpose and survey completion was provided in the Letter for Pilot Study Participants (Appendix C).

After final revision of the survey based on pilot study results, 500 surveys were mailed to a random, computer generated sample of ENA members. The cover letter provided directions for survey completion and return. A pre-stamped and addressed envelope was included with each survey. The participant was requested to return the survey within one week of receipt. Dillman (1978) suggests that most people who answer surveys do so almost immediately after receipt. A survey that remains unanswered for greater than a week is not very likely to be returned. Thus, a follow-up postcard (Appendix D) was mailed to all study participants one week after the original surveys were mailed. This follow-up provided an opportunity for the investigator to appeal for the return of the survey, using a slightly different approach.

The postcard follow-up was not written to overcome resistance, but rather to jog memories and rearrange participant priorities. It was timed to arrive within one week after the original survey, an appropriate time interval for conveying a sense of importance to the survey return without the investigator appearing impatient or unreasonable (Dillman, 1978). The main reason for choosing a postcard, rather than letter format, was convenience to both the investigator and participant. Also, the postcard introduced variety by contrasting with the envelope used for mailing the original survey.

## Human Subjects

University of Washington Forms EX-1 and 1311 were submitted to the University of Washington Human Subjects Committee for approval. Exempt status was requested as no vulnerable subjects were participating in the study. Participation in the study was

strictly voluntary and anonymous. The participant's consent was implied when he/she completed and returned the survey. Both men and women participated.

Risk/Benefit Ratio

The study did not expose its participants to any additional risk, stress, or discomfort beyond what is normally associated with completing a survey. The survey questions did require the participant to provide their attitudes, beliefs, and opinions of IOI, and relate their personal experiences in clinical practice, but no questions requested sensitive or potentially embarrassing information. The knowledge gained from this study will benefit emergency nurses and other emergency healthcare providers in their ability to provide quality patient care during pediatric resuscitation.

Protection of Subjects

Anonymity of each participant was guaranteed as no identification numbers or markings were on the surveys. Participants requesting a copy of a summary of the study results were provided a separate index card on which to write their name and address. The survey and index card were separated immediately after the return envelope was opened by a disinterested volunteer. The participant also had the option of returning the index card separately from the completed survey. Follow-Up postcards were sent to all study participants as there was no method to identify participants who had already returned their surveys.

## Plan for Analysis

Descriptive and comparative information from the surveys was quantified for each of the four variables affecting procedure use: the emergency nurse, their use of IOI,

their education and training in IOI, and the institutional policies of the work area in which they practiced. To describe emergency nurses who do or do not use IOI, respondents were classified according to use (questions # 10 and 11), and a profile of the nurses' gender (question # 8), age (question # 7), status (question # 1), area of practice (question # 2), type of facility (question # 3), number of years in the healthcare field (question # 6), number of annual pediatric resuscitations (question # 9), and state of practice (question # 4) was obtained using frequency measures.

For respondents who had either assisted with or performed and assisted with IOI, the clinical conditions of use (questions # 12 through 16) were obtained. IOI education and training (questions # 17 and 18), and institutional policies (questions # 19 through 22) were obtained for both IOI users and non-users and were described with frequency measures. Personal experiences and open ended responses were content analyzed with the following questions to guide analysis: what themes were apparent in the data, and how were they patterned? According to Polit and Hungler (1991), a theme is a molar unit of analysis; it might be a phrase, sentence, or paragraph embodying ideas or making an assertion about some topic. The frequency with which certain themes or relations were supported by the data were tabulated and content analyzed. The quantitative data obtained from the surveys was analyzed using descriptive statistical methods found in the Statistical Package of the Social Sciences (SPSS).

# Chapter IV

# Results

## Introduction

A survey to identify variables affecting the use of IOI during pediatric resuscitation was mailed to 500 randomly selected Emergency Nurses Association (ENA) members who met the inclusion criteria. A total of 243 (48.6%) surveys were returned within three months of the original mailing. Two surveys were returned unanswered; the individuals sent a written note explaining they were retired from nursing practice. The remaining 241 surveys (48.2%) were complete and were included in the data analysis. Requests for a copy of the summary of the study results were received from 72 (29.9%) participants. This chapter will present a description of the survey sample compared with the ENA sample demographics and results obtained.

## Description of the Sample

Table 3 summarizes characteristics of the survey sample as well as ENA demographics. ENA membership data were based on the 1995 Demographic Survey results in which 5679 (22.9% of total membership) ENA members responded to a survey of the membership. Geographic distribution of members was based on the ENA memberships counts provided by state councils and excluded ENA members not residing in the United States. Demographic characteristics analyzed included participant gender, age, status (or position), area of practice, type of facility in which employed, number of years in the healthcare field, number of annual pediatric resuscitations, and state of practice. The use of ENA membership data does not imply ENA review or endorsement of this study.

TABLE 3. Demographic Characteristics of the Survey Sample Compared With ENA Membership

| Demographic Variable | Sample Frequency (N=) | Sample Valid Percentage (%) | ENA Valid Percentage (%) | Difference [1] (%) |
|---|---|---|---|---|
| **Gender** | | | | |
| Male | 33 | 13.8 | 10.4 | 3.4 |
| Female | 207 | 86.2 | 89.6 | -3.4 |
| Missing | 1 | | | |
| **Age (Years)** | | | | |
| 20-29 | 15 | 6.3 | 5.3 | 1.0 |
| 30-39 | 81 | 34.0 | 34.4 | -0.4 |
| 40-49 | 107 | 45.0 | 44.0 | 1.0 |
| 50-59 | 32 | 13.4 | 14.3 | -0.9 |
| 60-69 | 3 | 1.3 | 1.9 | -0.6 |
| 70 + | 0 | 0 | 0.1 | -0.1 |
| Missing | 3 | | | |
| **Status (Position)** | | | | |
| Staff Nurse | 154 | 64.2 | 60.4 | 3.8 |
| Nurse Practitioner | 6 | 2.5 | 1.1 | 1.4 |
| Clinical Nurse Specialist | 9 | 3.8 | 2.3 | 1.5 |
| Manager/Administrator | 55 | 22.9 | 22.8 | 0.1 |
| Flight Nurse | 6 | 2.5 | N/A | N/A |
| Educator/Researcher | 7 | 2.9 | 7.5 | -4.6 |
| Other | 3 | 1.3 | 4.8 | -3.5 |
| Missing | 1 | | | |
| **Area of Practice** | | | | |
| Emergency Department | 222 | 92.5 | N/A | N/A |
| Aeromedical Evacuation Unit | 5 | 2.1 | N/A | N/A |
| Mobile Intensive Care Unit | 1 | 0.4 | N/A | N/A |
| Paramedic Unit | 2 | 0.8 | N/A | N/A |
| Other | 10 | 4.2 | N/A | N/A |
| Missing | 1 | | | |
| **Type of Facility** | | | | |
| Trauma Center Total (Sum of All Levels) | 90 | 38.8 | N/A | N/A |

TABLE 3. Demographic Characteristics of the Survey Sample Compared with ENA Membership, Continued

| Demographic Variable | Frequency (N=) | Sample Valid Percentage (%) | ENA Valid Percentage (%) | Difference[1] (%) |
|---|---|---|---|---|
| **Type of Facility, Continued** | | | | |
| Level I | 32 | 35.5 | 32.4 | 3.1 |
| Level II | 49 | 54.4 | 54.8 | -0.4 |
| Level III | 9 | 10.0 | 12.7 | -2.7 |
| University/ Teaching | 16 | 6.9 | N/A | N/A |
| Community | 100 | 43.1 | N/A | N/A |
| Children's | 3 | 1.3 | N/A | N/A |
| Military | 8 | 3.4 | 3.3 | 0.1 |
| Rural | 4 | 1.7 | N/A | N/A |
| Other | 11 | 4.7 | N/A | N/A |
| Missing | 9 | | | |
| **Years In Healthcare Field** | | | | |
| Less than 1 | 3 | 1.3 | 0.2 | 1.1 |
| 1-2 | 2 | 0.8 | 1.8 | -1.0 |
| 3-5 | 10 | 4.2 | 6.5 | -2.3 |
| 6-10 | 31 | 13.0 | 13.2 | -0.2 |
| 11-15 | 53 | 22.2 | 19.1 | 3.1 |
| 16-20 | 75 | 31.4 | 22.3 | 9.1 |
| 21-25 | 34 | 14.2 | 17.9 | -3.7 |
| 26-30 | 13 | 5.4 | 9.8 | -4.4 |
| 31 + | 18 | 7.5 | 8.8 | -1.3 |
| Missing | 2 | | | |
| **Number of Pediatric Resuscitations Per Year** | | | | |
| None | 24 | 10.0 | N/A | N/A |
| 1-5 | 131 | 54.6 | N/A | N/A |
| 6-10 | 54 | 22.5 | N/A | N/A |
| 11-15 | 16 | 6.7 | N/A | N/A |
| 16 + | 15 | 6.3 | N/A | N/A |

TABLE 3. Demographic Characteristics of the Survey Sample Compared with ENA Membership, Continued

| Demographic Variable | Frequency (N=) | Sample Valid Percentage (%) | ENA Valid Percentage (%) | Difference[1] (%) |
|---|---|---|---|---|
| **Region of Practice** | | | | |
| Northeast (ME, VT, NH, CT, MA, RI | 17 | 7.1 | 7.6 | -0.5 |
| Mid-Atlantic (NY, NJ, PA) | 35 | 14.6 | 17.4 | -2.8 |
| South Atlantic (DE, MD, DC, VA, WV, NC, SC, GA, FL) | 34 | 14.1 | 17.9 | -3.8 |
| East North Central (OH, IN, IL, MI, WI) | 39 | 16.3 | 16.5 | -0.2 |
| East South Central (KY, TN, AL, MS) | 15 | 6.3 | 5.0 | 1.3 |
| West North Central (MN, IA, MO, ND, SD, NE, KS) | 19 | 7.9 | 6.1 | 1.8 |
| West South Central (AR, LA, OK, TX) | 25 | 10.3 | 10.9 | -0.6 |
| Mountain (MT, ID, WY, CO, NM, AZ, UT, NV) | 15 | 6.2 | 6.2 | 0.0 |
| Pacific (WA, OR, CA, AK, HI) | 40 | 16.6 | 12.9 | 3.7 |
| Missing | 2 | | | |

[1] Difference equals sample valid percentage minus ENA valid percentage

Gender

The study sample consisted of 33 (13.8%) men and 207 (86.3%) women, with one participant leaving the gender question unanswered. This distribution was similar to ENA membership (10.4% males and 89.6% female).

Age

The age range of the study participants was from 20 to 69 years. Participant age was categorized into groups consistent with the ENA demographic data. The most frequently reported age range of the sample was the 40 to 49 year group (44.4%) while the least frequent range was the 60 to 69 year group (1.3%). A large number of respondents were in the 30 to 39 year group for both the survey sample (34%) and the ENA sample (34.4%). No study participants were in the under 20 years or greater than 70 years group. These numbers closely approximate the ENA sample.

Status (Position)

The majority of the study participants reported employment as a staff nurse (64.2%), whereas 22.9% were employed in management or administrative positions. Flight nurses (2.5%) were included in the study sample, but not the ENA sample; it is possible they were reported in the "Other" category in the ENA survey. Nurse educators/researchers were somewhat underrepresented in the study sample as compared to the ENA sample (2.9% versus 7.6%).

Area of Practice

The majority (92.5%) of nurses in the study sample were employed in the ED. A small number (3.3%), reported employment in the pre-hospital arena (aeromedical

evacuation, Mobile Intensive Care Unit, or paramedic unit). No data regarding area of practice were available in the ENA survey sample.

Type of Facility

The majority of nurses reported working in a community/private hospital (41.5%, n=100) followed closely by those employed in a Trauma Center (38.8%, N=90). Of those nurses working in trauma centers, 35.6% were employed in a Level I facility, 54.4% in a Level II facility, and 10% in a Level III facility. The Other category (4.7%, N=11) includes respondents working in prehospital and aeromedical evacuation units as well as free-standing clinics. Due to differences in type of facility categories between the study and ENA surveys, other comparisons could not be made.

Number of Years in Healthcare Field

The survey sample had a larger percentage of individuals in the 16 to 20 year experience group, with the ENA sample having more individuals with fewer years of experience and more individuals in the most experienced year groups. However, comparisons between the survey and ENA samples may be inaccurate as the study survey questioned the number of years the participant had been in the healthcare field, while the ENA survey questioned the number of years the participant had been a nurse. Such a discrepancy could possibly yield different results for those respondents who worked in a non-nursing area of the healthcare field before becoming a nurse.

Number of Pediatric Resuscitations Per Year

The majority of the study sample (54.6%) identified participating in one to five pediatric resuscitations per year while 22.5% reported participating in six to ten

resuscitations and 10% reported participating in no resuscitations. Only 13% of the sample participated in more than 11 pediatric resuscitations per year (6.7% reported 11 to 15 and 6.3% reported greater than 16 pediatric resuscitations per year). Because specific criteria for pediatric resuscitation were not defined in the current survey, this question could have been open to various interpretations: a critically ill or injured child may be considered "business as usual" at a Children's Hospital, but considered a major resuscitation at a small rural hospital with few pediatric patients. The ENA did not question survey respondents regarding the number of pediatric resuscitations, so no comparisons are available.

Region of Practice

The survey sample as well as the ENA sample were broadly distributed across the United States. Several states ( Idaho, Kansas, Montana, North Dakota, and Rhode Island) has no representation within the survey sample. The survey sample distribution by state was similar to ENA membership. Individual states were then grouped into nine regions defined by the United States Census Bureau (1995).

Specific Aim #1

The first specific aim of the study was to determine the extent to which IOI is currently being utilized by emergency nurses during pediatric resuscitation. The survey respondents were questioned regarding their use of IOI: had they ever performed the procedure, and had they ever assisted with the procedure. If the answer to either question was yes, the respondents were prompted to identify the number of times they had either performed and/or assisted with the procedure. Of the 240 valid responses, 74

(30.8%) had never performed or assisted with IOI, 112 (46.7%) had assisted with, but never performed, the procedure, and 52 (21.6%) had performed and assisted with IOI. An additional two (0.83%) respondents had performed but not assisted with IOI; this subset is included in the perform and assist group for a revised total of 54 (22.5%) in the perform and assist group (Figure 2).

Use of IOI

For those 74 nurses who had never performed or assisted with IOI, the majority (N=41, 55.4%) had been trained in IOI, but had not yet had the opportunity to perform or assist with the procedure. Other factors related to the failure to use IOI included lack of training or restrictive institutional policies. Only one respondent had not heard of the procedure (Figure 3). The 74 respondents who had never performed IOI were prompted to skip those survey questions which alluded to IOI use.

Of the 112 respondents who had assisted with IOI, 96 (85.7%) had assisted with five or less, and five (4.5%) with between six and nine procedures. Eleven respondents (9.8%) had assisted with ten or more IOI procedures. Of the 54 respondents who reported both performing and assisting with IOI, 18 (33.3%) had performed/assisted with one to five procedures, nine (16.7%) with six to nine procedures, 21 (38.9%) with 10 to 20 procedures. Six respondents (11.1%) reported performing and assisting with over 20 IOI procedures.

Time Elapsed

Several survey questions were designed to determine if the respondents used specific criteria in their decision to use IOI. Respondents who had performed or

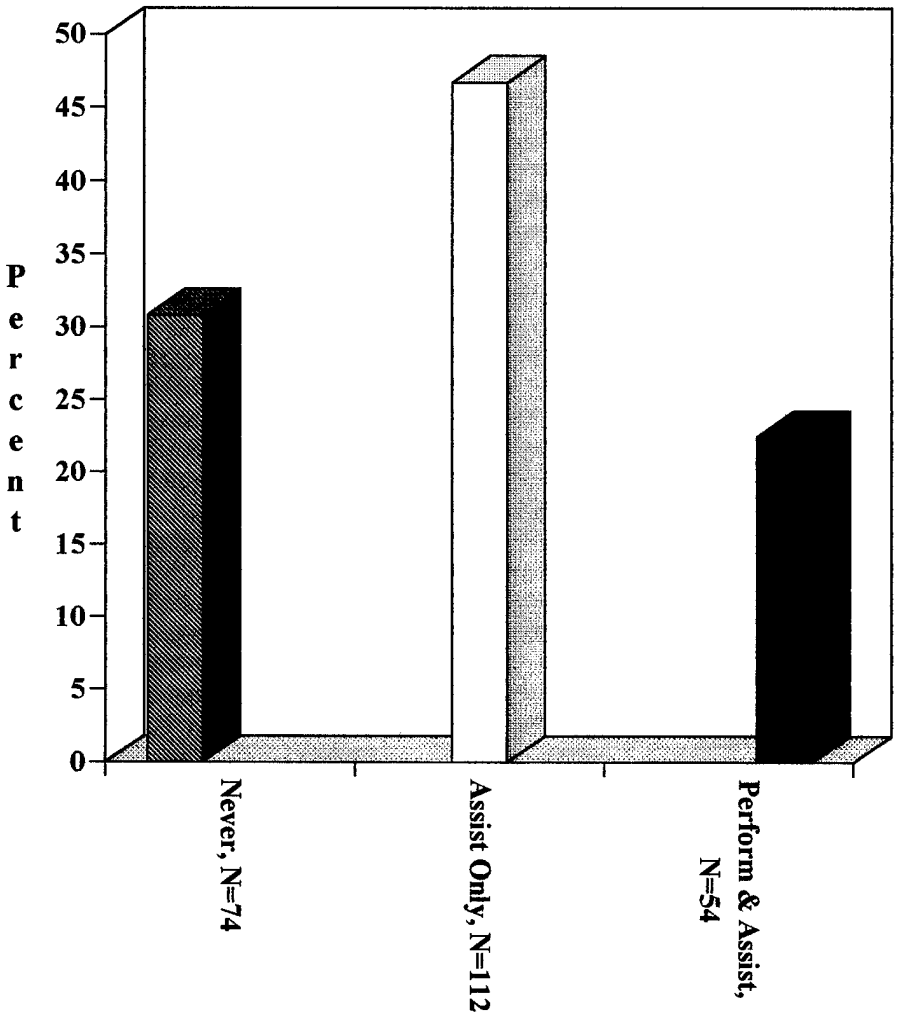


FIGURE 2. Distribution of Experiences of the Sample with Intraosseous Infusion.

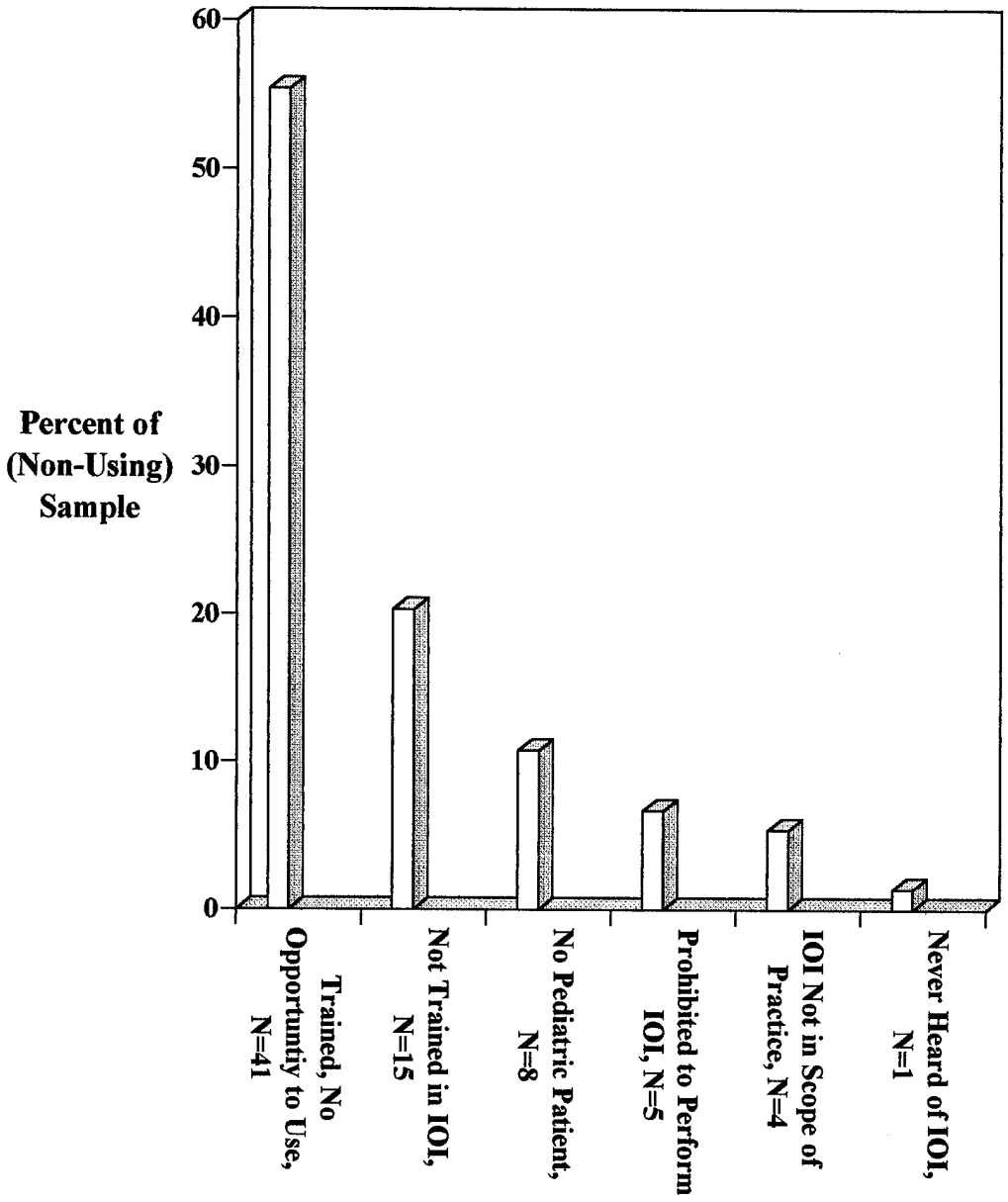


FIGURE 3. Rationale For Lack of Participation With Intraosseous Infusion (IOI) Reported by the 74 Respondents Who Had Never Used the Procedure.

assisted with IOI were asked if they used IOI after a specific amount of time had elapsed without successful intravascular access being obtained. Of the 162 valid responses, 88 (54.3%) stated that time was not a factor in their decision to use IOI; 74 (45.7%) stated that time was a factor. These 74 respondents were then asked to provide the specific time (in minutes) of unsuccessful IV attempts, before deciding to use IOI (Figure 4). The decision to use IOI was most frequently made after five to ten minutes without intravascular access, though many respondents reported the decision to use IOI was made after two minutes had elapsed. More nurses who had assisted only reported using IOI after five to ten minutes, while more nurses who had performed and assisted reported using IOI after two minutes had elapsed.

Number of IV Attempts

Survey respondents were also questioned as to whether a certain number of attempts at peripheral IV access was a factor in their use of IOI. Out of 163 valid responses, 139 (85.3%) stated that the number of unsuccessful attempts at peripheral IV access was a factor in their use of IOI. These 139 respondents were then asked to provide the number of unsuccessful IV attempts before deciding to use IOI (Figure 5). The majority reported using IOI after two to three unsuccessful peripheral IV attempts.

Central Line/Peripheral Cutdown

Emergency nurses' use of IOI after a physician's unsuccessful attempt at central line placement or peripheral cutdown was also questioned. Of the 164 valid responses to the question regarding central lines, 16 (9.8%) reported using IOI after an unsuccessful attempt at central line placement. When questioned regarding use of IOI

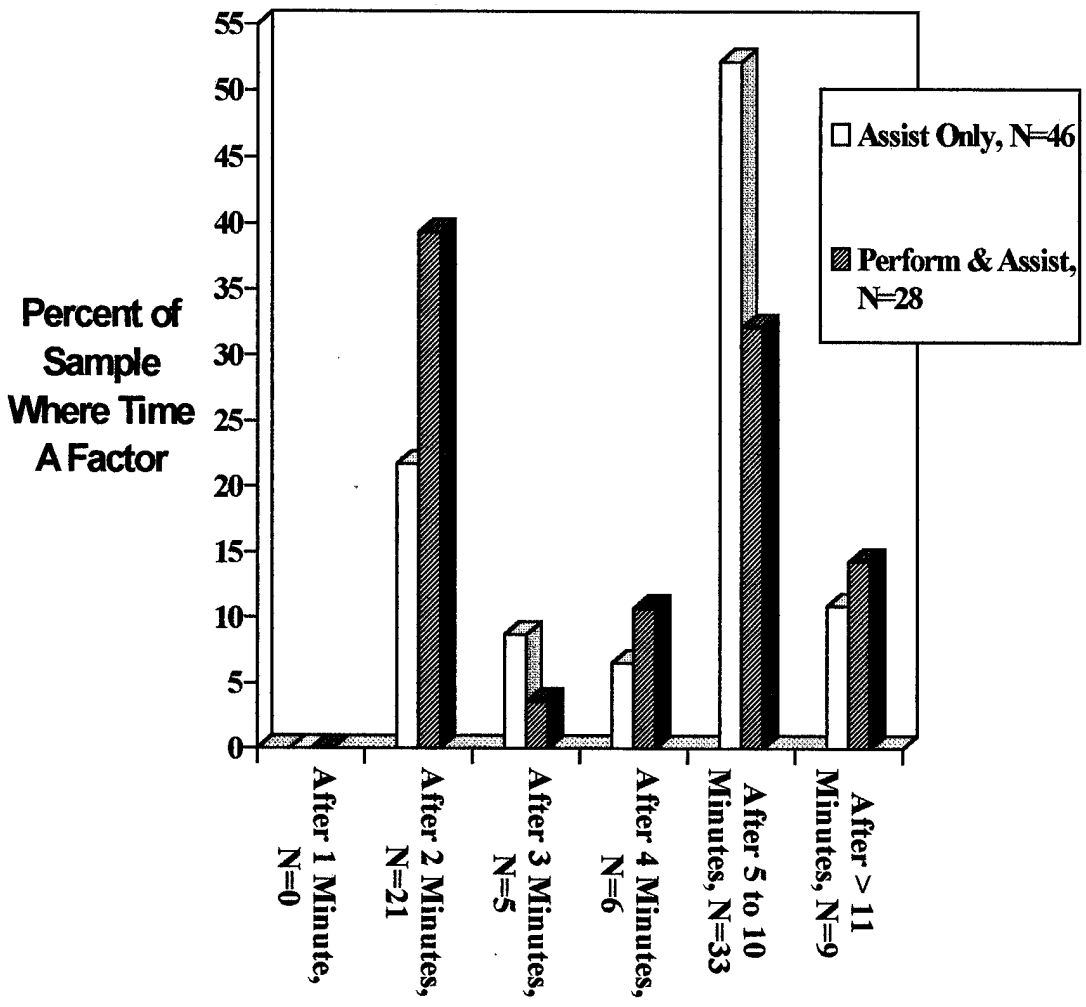


FIGURE 4. Comparison of Reported Times Elapsed (From Initiation of Attempts at Intravascular Access to Decision to Use Intraosseous Infusion) Among Two Groups of Intraosseous Infusion Users (N=74).

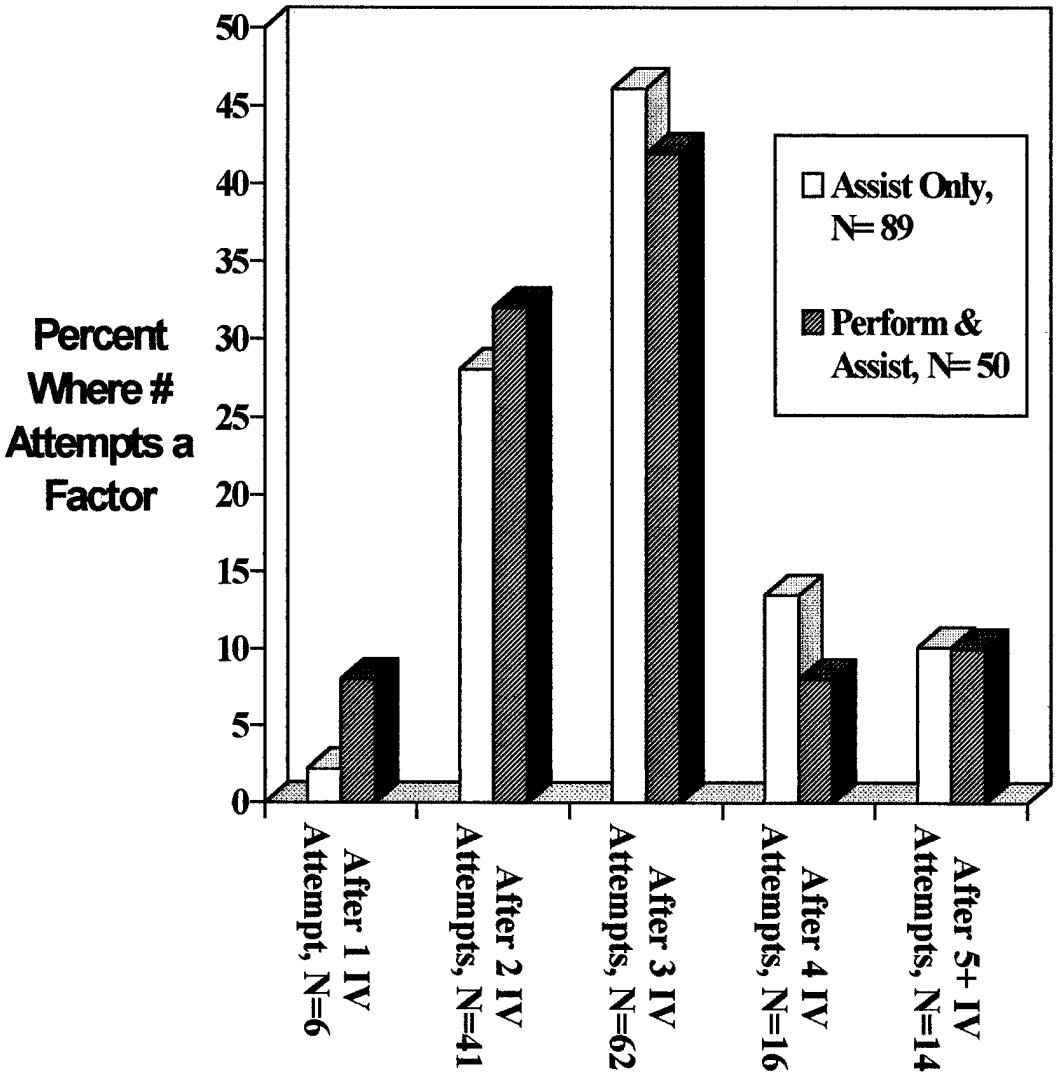


FIGURE 5. Comparison of Number of Unsuccessful Intravenous (IV) Attempts Prior to Decision to Use Intraosseous Infusion Reported by Two Groups Of Intraosseous Infusion Users (N=139).

after an unsuccessful attempt at peripheral cutdown, 11 (6.7%) of the respondents replied positively.

Other

The survey prompted respondents to write in any other criteria they had used when determining whether to use IOI. Nine respondents (5.5%) reported they had used IOI when pediatric patients arrived in the ED with no apparent peripheral veins and multiple attempts at peripheral IV access by the EMS had been unsuccessful.

Clinical Conditions of IOI Use

Those respondents (N=165) who had either assisted with or performed IOI were questioned regarding the clinical conditions surrounding their use of the procedure (Table 4). IOI was most commonly used for IV fluids; IV medication use was also common while blood product infusion was rare (nurses were able to select more than one substance). Both the assist only and perform and assist groups used IOI similarly with respect to products infused.

Pediatric cardiac arrest (from whatever cause) was the most frequently listed condition where the emergency nurse used IOI; it was also frequently used during pediatric respiratory arrest (from whatever cause). Several respondents wrote in patient conditions in which they had used IOI: five nurses (3%) reported IOI use in pediatric patients with status epilepticus, and two (1.1%) assisted with IOI in unresponsive newborns.

While the majority of respondents reported assisting with or performing IOI in the ED, others reported use of IOI in the field, during patient transport, or a combination

TABLE 4. Comparison of Characteristics Related to Intraosseous Infusion (IOI) Use Among Respodents Who Assisted Versus Performed and Assisted

| | Frequency (N=) | Assist Only (%) | Perform & Assist (%) |
|---|---|---|---|
| **Substances Infused**[1] | | | |
| IV Fluids | 161 | 97.3 | 98.1 |
| IV Medications | 122 | 70.3 | 81.5 |
| Blood/Blood Products | 17 | 8.1 | 14.8 |
| **Selected Patient Conditions**[1] | | | |
| Cardiac Arrest | 120 | 67.6 | 83.3 |
| Respiratory Arrest | 107 | 64.5 | 66.7 |
| Shock | 59 | 33.3 | 40.7 |
| Drowning/Near Drowning | 56 | 31.5 | 39.6 |
| Burns | 19 | 6.3 | 22.2 |
| Multiple Trauma | 16 | 9.0 | 11.1 |
| **Location** | | | |
| Emergency Dept. | 151 | 97.3 | 79.6 |
| In "The Field" | 2 | 0 | 3.7 |
| Multiple (ED, Field, During Transport) | 11 | 1.8 | 16.7 |
| Delivery Room | 1 | 0.9 | 0 |
| **Patient Age** | | | |
| Newborn to 5 Years | 143 | 89.8 | 85.2 |
| 6+ Years | 19 | 10.2 | 14.8 |

[1] Respondents may have selected more than one response

of the three locations. One respondent reported assisting with IOI in the Delivery Room.

The majority of respondents (88.3%) reported IOI use in patient up to five years of age, and 11.7% reported IOI use in children over six years of age. Nurses who had performed and assisted with IOI reported a higher use rate in older (age six years and above) children than respondents who had assisted only.

Specific Aim #2

The second specific aim of this study was to compare demographic variables for nurse who do versus those who do not use IOI. Nurses using IOI were subdivided into those who had never used IOI, those who had assisted only and those who had performed and assisted with the procedure (Table 5).

Similar percentages of nurses of each gender had no experience with IOI. Among males, of those with IOI experience, similar numbers of subjects had assisted only versus performed. However, experience was somewhat different among the females in that more than two times as many had assisted only versus performed the procedure. Respondents of all ages assisted with the procedure more often than they performed IOI. The highest prevalence of procedure use was in the 30 to 39 year group. Nurses 40 years and older were more likely to have never used the procedure than nurses under 39 years of age.

Staff nurses and Nurse Practitioners were the least commonly involved in IOI procedures. All flight nurse respondents had performed the procedure. It is unknown whether the high use rate reported by nurse managers, educators, and researchers is a reflection of their practice in their current position, or of a previous role as a staff nurse.

TABLE 5. Demographics of Intraosseous Infusion (IOI) Non-Users Versus Two Groups of IOI Users

| | Frequency (N=) | Never Used (%) | Assist Only (%) | Perform & Assist (%) |
|---|---|---|---|---|
| **Gender** | | | | |
| Male | 33 | 24.2 | 39.4 | 36.4 |
| Female | 206 | 31.5 | 48.1 | 20.4 |
| **Age (Years)** | | | | |
| 20-29 | 15 | 26.7 | 53.3 | 20 |
| 30-39 | 81 | 19.8 | 48.1 | 32.1 |
| 40-49 | 107 | 38.3 | 46.7 | 15 |
| 50-59 | 31 | 35.5 | 38.7 | 25.8 |
| 60-69 | 3 | 33.3 | 66.7 | 0 |
| **Status (Position)** | | | | |
| Staff Nurse | 153 | 34 | 42.5 | 23.5 |
| Nurse Practitioner | 6 | 50 | 33.3 | 16.7 |
| Clinical Nurse Specialist | 9 | 22.2 | 66.7 | 11.1 |
| Manager/Administrator | 55 | 21.8 | 65.5 | 12.7 |
| Flight Nurse | 6 | 0 | 0 | 100 |
| Educator/Researcher | 7 | 14.2 | 42.9 | 42.9 |
| **Area Of Practice** | | | | |
| Emergency Department | 221 | 29 | 50.2 | 20.8 |
| Aeromedical Evacuation | 5 | 0 | 0 | 100 |
| Mobile Intensive Care Unit | 1 | 0 | 0 | 100 |
| Paramedic Unit | 2 | 50 | 0 | 50 |
| **Type Of Facility** | | | | |
| Level I Trauma Center | 32 | 18.8 | 62.4 | 18.8 |
| Level II Trauma Center | 48 | 20.8 | 50 | 29.2 |
| Level III Trauma Center | 9 | 44.4 | 11.2 | 44.4 |
| University/Teaching | 16 | 25 | 62.5 | 12.5 |
| Community | 100 | 30 | 47 | 23 |
| Children's | 3 | 33.3 | 0 | 66.7 |
| Military | 8 | 25 | 50 | 25 |
| Rural | 4 | 75 | 25 | 0 |

TABLE 5. Demographics of IOI Non-Users Versus Two Groups of IOI Users, Continued

| | Frequency (N=) | Never Used (%) | Assist Only (%) | Perform & Assist (%) |
|---|---|---|---|---|
| **Years In Healthcare Field** | | | | |
| Less Than 1 | 3 | 100 | 0 | 0 |
| 1-2 | 2 | 100 | 0 | 0 |
| 3-5 | 10 | 0 | 90 | 10 |
| 6-10 | 31 | 26 | 52 | 22 |
| 11-15 | 52 | 23 | 37 | 40 |
| 16-20 | 75 | 35 | 44 | 21 |
| 21-25 | 34 | 35 | 59 | 6 |
| 26-30 | 13 | 31 | 54 | 15 |
| 31+ | 18 | 28 | 44 | 28 |
| **Number of Pediatric Resuscitations Per Year** | | | | |
| None | 24 | 79.1 | 16.7 | 4.2 |
| 1-5 | 131 | 35.9 | 48.1 | 16 |
| 6-10 | 54 | 13 | 50 | 37 |
| 11-15 | 16 | 0 | 68.8 | 31.2 |
| 16+ | 14 | 0 | 50 | 50 |
| **Region of Practice** | | | | |
| Northeast (ME, VT, NH, CT, MA, RI) | 17 | 23.5 | 58.8 | 17.7 |
| Mid-Atlantic (NY, NJ, PA) | 35 | 34.3 | 54.3 | 11.4 |
| South Atlantic (DE, MD, DC, VA, WV, NC, SC, GA, FL) | 34 | 14.7 | 47.1 | 38.2 |
| East North Central (OH, IN, IL, MI, WI) | 39 | 38.5 | 51.3 | 10.2 |
| East South Central (KY, TN, AL, MS) | 15 | 46.7 | 33.3 | 20 |

TABLE 5. Demographics of IOI Non-Users Versus Two Groups of IOI Users, Continued

| | Frequency (N=) | Never Used (%) | Assist Only (%) | Perform & Assist (%) |
|---|---|---|---|---|
| **Region of Practice, Continued** | | | | |
| West North Central (MN, IA, MO, ND, SD, NE, KS) | 19 | 31.6 | 31.6 | 36.8 |
| West South Central (AR, LA, OK, TX) | 25 | 40 | 36 | 24 |
| Mountain (MT, ID, WY, CO, NM, AZ, UT, NV) | 15 | 6.7 | 33.3 | 60 |
| Pacific (WA, OR, CA, AK, HI) | 40 | 33.3 | 53.9 | 12.8 |

For survey respondents who worked in an ED, 71% had used IOI. Twice as many ED nurses assisted with the procedure than performed IOI. All respondents who worked in an Aeromedical Evacuation Squadron and MICU had performed the procedure. IOI experience was more common in nurses working in major (Level I or II) trauma centers, as well as University-affiliated and military facilities, and nurses working in rural facilities reported the lowest use of the procedure.

Those newly entering the healthcare field (less than three years experience) reported no experience with IOI. Nurses with three to five years of healthcare experience reported a high rate of assisting with the procedure, while nurses with 11 to 15 years of experiences reported the highest rate of performing and assisting with IOI.

The proportion of respondents who have a greater number of pediatric resuscitations per year increases with the proportion of respondents who have experience with IOI (test for trend Chi Square=40.4, $p<0.001$). Of those nurses who reported participating in no pediatric resuscitations, only 20.9% had used the procedure, while nurses annually participating in one to five resuscitations reported a 64.1% use rate. When the number of resuscitations was six to ten, the use rate rose to 87%; greater than ten resuscitations, the use rate was 100%.

As many of the states were represented by a small number of respondents, states were grouped into nine regions as defined by the U.S. Census Bureau (1995). Regional differences were apparent with use rates ranging from 53.3% in the East South Central region to 93.3% use rates in the Mountain states.

Specific Aim # 3

The third specific aim of the study was to determine the emergency nurse's education and training in IOI technique (Table 6). A large majority of the respondents (89.2%) had received training in IOI and nurses who were trained in the procedure reported a higher rate of participation than nurses without prior training.

Nurses with previous training were then asked to rate their perception of the training's effectiveness and realism. More than a quarter of the respondents (27%) rated their training as very effective and realistic, half (50.5%) rated their training as effective and realistic, 15.7% as not at all effective or realistic and 6.8% were unsure. Nurses who perceived their IOI training as effective and realistic or very effective and realistic reported a higher rate of use than nurses who reported their training as not effective or realistic.

Nurses who had received training in IOI were also questioned regarding the sources of their training and the methods used to obtain the training. Many of the respondents had received their training from several different sources (Figure 6). A majority of the respondents with training in IOI (61.4%) received their training in a Pediatric Advanced Life Support (PALS) course, while relatively few (5.1%) had received IOI training in Nursing School. Use of IOI by source of training is presented in Table 6.

Several methods of IOI training were noted and many respondents reported that a combination of the methods were used to accomplish training. Although there was little difference in actual IOI use among the methods of instruction, a greater number of nurses (31.5%) who had practiced with a chicken or turkey leg bone reported later

TABLE 6. Education and Training of Intraosseous Infusion (IOI) Non-Users Versus Two Groups of IOI Users

| | Frequency (N=) | Never Used (%) | Assist Only (%) | Perform & Assist (%) |
|---|---|---|---|---|
| **Prior IOI Training** | | | | |
| Yes | 214 | 24.3 | 50.5 | 25.2 |
| No | 26 | 84.6 | 15.4 | 0 |
| **Perception of IOI Training** | | | | |
| Very Effective/Realistic | 55 | 9.1 | 47.3 | 43.6 |
| Effective/Realistic | 103 | 25.2 | 47.6 | 27.2 |
| Not Effective/Realistic | 32 | 25 | 75 | 0 |
| Unsure | 14 | 92.9 | 7.1 | 0 |
| **IOI Use By Source of Training**[1] | | | | |
| PALS | 132 | 25 | 41.7 | 33.3 |
| Inservice | 78 | 11.5 | 52.6 | 35.9 |
| TNCC | 70 | 20 | 51.4 | 28.6 |
| ENPC | 53 | 22.7 | 41.5 | 35.8 |
| ATLS | 34 | 20.6 | 47.1 | 32.3 |
| BTLS | 21 | 14.3 | 33.3 | 52.4 |
| Nursing School | 11 | 36.4 | 54.5 | 9.1 |
| **Method of IOI Training** | | | | |
| Lecture | 188 | 24.5 | 48.4 | 27.1 |
| Audio/Visual | 82 | 18.3 | 52.4 | 29.3 |
| Printed Material | 121 | 24 | 52 | 24 |
| Skills Practice-Bone Manikin | 165 | 22.4 | 46.1 | 31.5 |
| Skills Practice-IOI | 59 | 23.7 | 40.7 | 35.6 |

Table 6. Education and Training of IOI Non-Users Versus Two Groups of IOI Users, Continued

| | Frequency (N=) | Never Used (%) | Assist Only (%) | Perform & Assist (%) |
|---|---|---|---|---|
| **Length of IOI Training** | | | | |
| Less Than 1 Hour | 18 | 38.9 | 50 | 11.1 |
| 1 Hour | 45 | 35.6 | 37.8 | 26.6 |
| 2 Hours | 55 | 16.4 | 54.5 | 29.1 |
| 3 Hours | 10 | 30 | 40 | 30 |
| 4 Hours | 20 | 40 | 20 | 40 |
| 5+ Hours | 9 | 11.1 | 22.2 | 66.7 |

[1] PALS, Pediatric Advanced Life Support; TNCC, Trauma Nurse Core Course; ENPC, Emergency Nurse Pediatric Course; ATLS, Advanced Trauma Life Support; BTLS, Basic Trauma Life Support

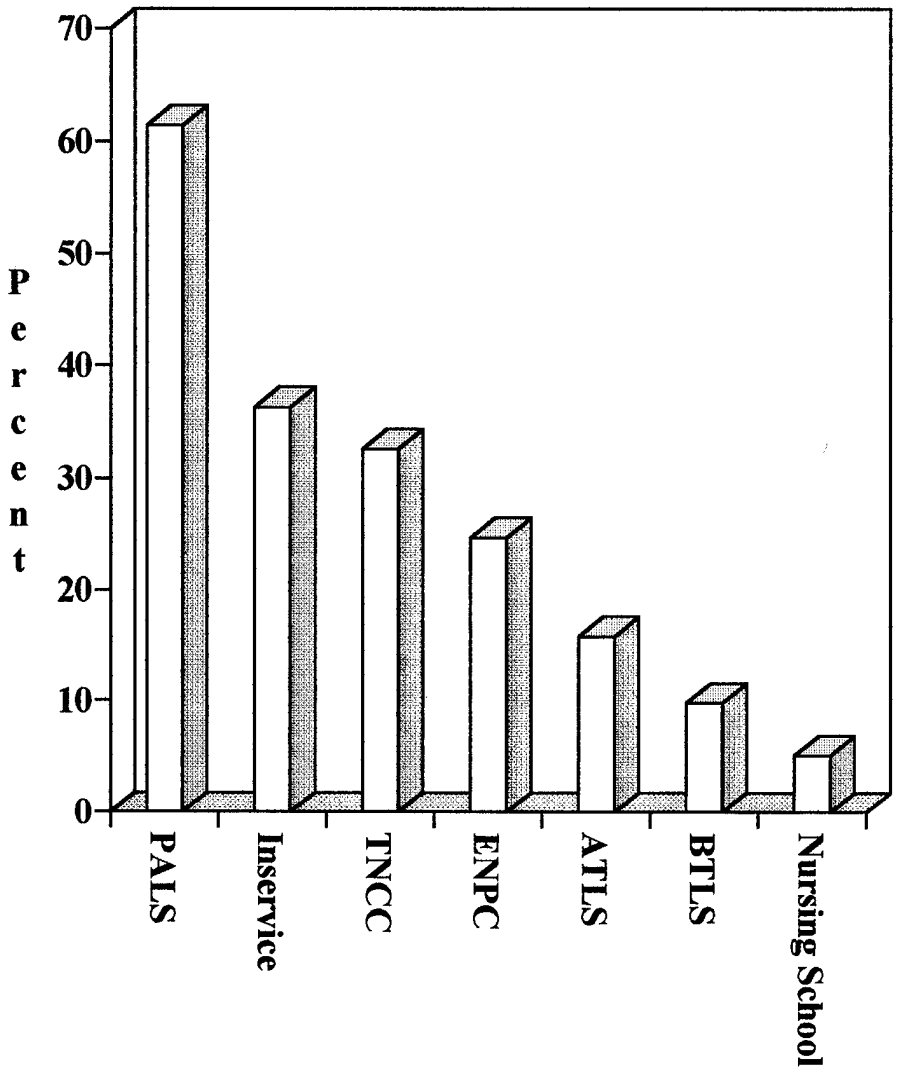


FIGURE 6. Source s Of Intraosseus Infusion Training and Percent of Sample Trained in Each ( Note: Respondents May Have Selected More Than One Source of Training). PALS, Pediatric Advanced Life Support; TNCC, Trauma Nurse Core Course; ENPC, Emergency Nurse Pediatric Course; ATLS, Advanced Trauma Life Support; BTLS, Basic Trauma Life Support.

performing the procedure, than those nurses who had not had the opportunity to practice the skill (4.2%). A difference in actual performance rate was also noted between those who had practiced on an IO manikin (35.6%) than those who had not (21.6%). The opportunity to practice IOI technique skills during training appears to be an important factor in its subsequent use, rather than the actual method of instruction.

The majority of respondents who had been trained in IOI reported a training length of two hours (35.0%) followed by one hour of training (28.7%). While it is unclear if the hours of training were from one course, or represented the total hours from several different courses, it is apparent that increased training times are a factor in the use of IOI.

Specific Aim #4

The fourth specific aim of the study was to determine the institutional policies guiding the emergency nurse's use of IOI. The presence of an IOI protocol and IOI equipment in a work area, the institutional recommendation of IOI as an alternate means of intravascular access, and the provision of IOI training in the work area were explored to determine if institutional policies were a factor in emergency nurses' use of IOI (Table 7). IOI protocols were present in the work areas of 55.2% of the respondents; 31.8% of the nurses stated their work areas did not have an IOI protocol, and 13% did not know if a protocol was present. Only small differences were noted in use rates in areas with and without an IOI protocol.

However, the availability of IOI equipment in the work area appears to be a strong factor in the nurse's use of IOI. The majority of respondents (93.7%) reported that IOI

TABLE 7. Institutional Policies of Intraosseous Infusion (IOI) Non-Users Versus Two Groups of IOI Users

| | Frequency (N=) | Never Used (%) | Assist Only (%) | Perform & Assist (%) |
|---|---|---|---|---|
| **IOI Protocol** | | | | |
| Yes | 132 | 26.5 | 47.7 | 25.8 |
| No | 76 | 32.9 | 44.7 | 22.4 |
| Don't Know | 31 | 45.2 | 45.2 | 9.6 |
| **IOI Equipment Available** | | | | |
| Yes | 224 | 26.3 | 49.6 | 24.1 |
| No | 13 | 100 | 0 | |
| Don't Know | 2 | 100 | 0 | |
| **IOI Recommended** | | | | |
| Yes | 174 | 21.8 | 49.4 | 28.8 |
| No | 26 | 53.8 | 38.5 | 7.7 |
| Don't Know | 36 | 55.6 | 38.9 | 5.5 |
| **IOI Training Provided** | | | | |
| Yes | 107 | 21.5 | 44.9 | 33.6 |
| No | 113 | 36.3 | 47.8 | 15.9 |
| Don't Know | 16 | 43.8 | 56.2 | 0 |

equipment was available in their work area; 5.4% of the respondents reported IOI equipment was not available, and 0.9% were unsure. Of the nurses who reported that IOI equipment was not available, or were unsure of its availability, 100% had never used the procedure; 73.7% of the nurses with equipment available had used IOI.

The majority of respondents (73.7%) reported that IOI was recommended by their work area for use during pediatric resuscitation; 11.0% reported that IOI was not recommended, and 15.3% were unsure. Use of IOI was higher in work areas where it was recommended; use dropped to 46.2% in areas were it was not specifically recommended and in those work areas where its recommendation was unknown.

Only 45.3% of respondents reported that IOI training was provided by their employer, while 47.9% reported no training was available, and 6.8% did not know. For those nurses whose employers provided IOI training, the use rate was 78.5% compared with 63.7% for those where training was not available, and 56.2% for those who were unsure. This survey question is open to several interpretations: many respondents reported education and training in IOI in courses that were held at their place of employment, but the nurses attended the course on their own time and at their own expense. Others may have assumed this question referred to training that occurred in their immediate work area and not as part of a specific course. Other nurses may have attended courses at facilities other than their place of employment. However, the availability of training at one's own institution (from whatever training source) appears to be an important factor in the emergency nurse's use of IOI.

## Specific Aim #5

The fifth specific aim of the study was to determine factors that encourage the use of IOI by emergency nurses. Nurses were asked to respond to open-ended questions regarding what they like about IOI, and what factors they believed encouraged IOI use by themselves or other emergency nurses. Many of the respondents who had never used IOI either did not answer these questions, or wrote in "Not Applicable".

In response to the question, "What do you like about IOI?", 178 nurses wrote in their opinions. Two categories, "quick/rapid" (35.4%) and "easy/simple" (30.9%) or their combination, "quick and simple" (66.3%), were most often listed. Even separated, these categories comprise a significant proportion of the total responses, and attests to the nurses' belief that the procedure is rapid and simple. Others appreciated the easy accessibility of IOI sites and their ability to use large bore IO needles (16.3%) as well as the convenience of infusing any fluid or medication (9.6%) through an IO line. A small percent (3.9%) appreciated IOI as an alternate to peripheral IV access; likewise, 3.9% reported that they did not like anything about IOI.

Similarly, 178 nurses responded to the question regarding what factors or circumstances they thought encouraged emergency nurses to use the IOI (Figure 7). Many (34.3%) described IOI as a valuable alternate to peripheral IV access with high success rates and the potential to be a life-saving procedure during pediatric resuscitation. The support of healthcare colleagues, whether through seeing other nurses or physicians using the procedure, hospital administration approval, or the availability of IOI policy and procedure guidelines was an important factor to 20.3% of the

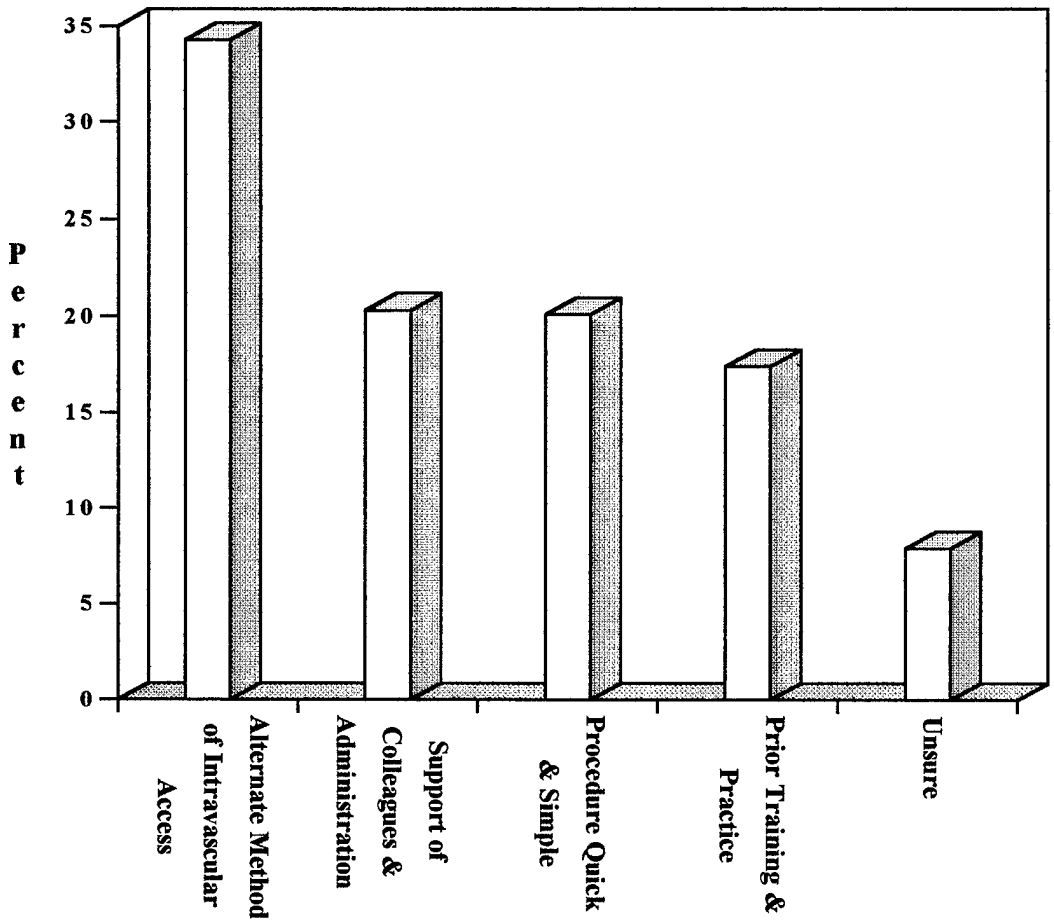


FIGURE 7. Factors Which Encourage the Use of the Intraosseous Infusion By Emergency Nurses (Groupings Applied to Respondents' Answers to Open-Ended Questions).

respondents. Similarly, 20.1% reported rapidity, simplicity, and accessibility of the procedure as an incentive for its use. Prior training and practice in the procedure provided encouragement to 17.4% of the respondents. Only a few (7.9%) reported they were unsure of encouraging factors.

Specific Aim #6

The sixth specific aim of the study was to determine potential barriers to the use of IOI by emergency nurses. Respondents were asked open-ended questions regarding what they disliked about IOI, what factors or circumstances they believed were barriers to, or discouraged, the use of IOI, and if they believed IOI was underutilized during pediatric resuscitation.

There were 177 responses to the open-ended question regarding what was disliked about IOI. All but 24 (13.5%) of the respondents to this question had used the procedure. The invasiveness of the procedure was reported by 23.2% of the respondents: many disliked the idea of inserting a needle into a bone, and being unable to see or feel where the needle was going; others in this category disliked the sound of the insertion into bone. Many nurses reported disliking the reluctance of healthcare colleagues to use the IOI: 14.6% wrote that the procedure was not used often enough or was used only as a last resort.

The difficulty in securing an IOI line was viewed as a detriment by 14.1% of the respondents. Potential patient complications and pain caused by the procedure were concerns reported by 13.5%. Technical aspects of IOI, such as its short-term use, difficulty in insertion, IO needles bending, and difficulty in achieving an adequate fluid

flow rate was listed by 9.7% of the respondents. A lack of support for RN use of the procedure, as evidenced by nurses not being allowed to use IOI, or being criticized for its use, was voiced by 1.2%. However, 20.3% of the respondents reported there was nothing that they disliked about the procedure.

The question regarding barriers to the use of IOI was answered by 188 respondents. Many (40.9%) reported a lack of knowledge, training, and practice was the greatest barrier to IOI use; others (28.2%) cited fear, discomfort, or intimidation with the procedure as a deterrent. Additionally, some (5.3%) reported that they detected discomfort with the procedure in physician colleagues, and speculated that this also created a barrier. A lack of support for the procedure, as evidenced by nurses not being allowed to perform IOI, a lack of policy and procedures, or a lack of administrative support was indicated by 20.7% of the respondents as a barrier to IOI use. A small percentage of the respondents (4.8%) perceived the invasiveness of IOI as a barrier to its use. Technical difficulties related to the procedure, such as the difficulty in inserting or securing an IOI line was listed by 2.7% of the respondents. An equal number described the perception that IOI was a "last resort" as a barrier as well as the perception by some emergency staff that peripheral IV access could be obtained if they "just kept trying" (Figure 8).

Of 187 responses to the question regarding underutilization of IOI, 20.9% of the nurses stated they believed IOI was utilized properly, at least at their own institution. However, 79.1% of the respondents indicated that IOI was indeed underutilized. Reasons listed by respondents for its underutilization included a lack of training and

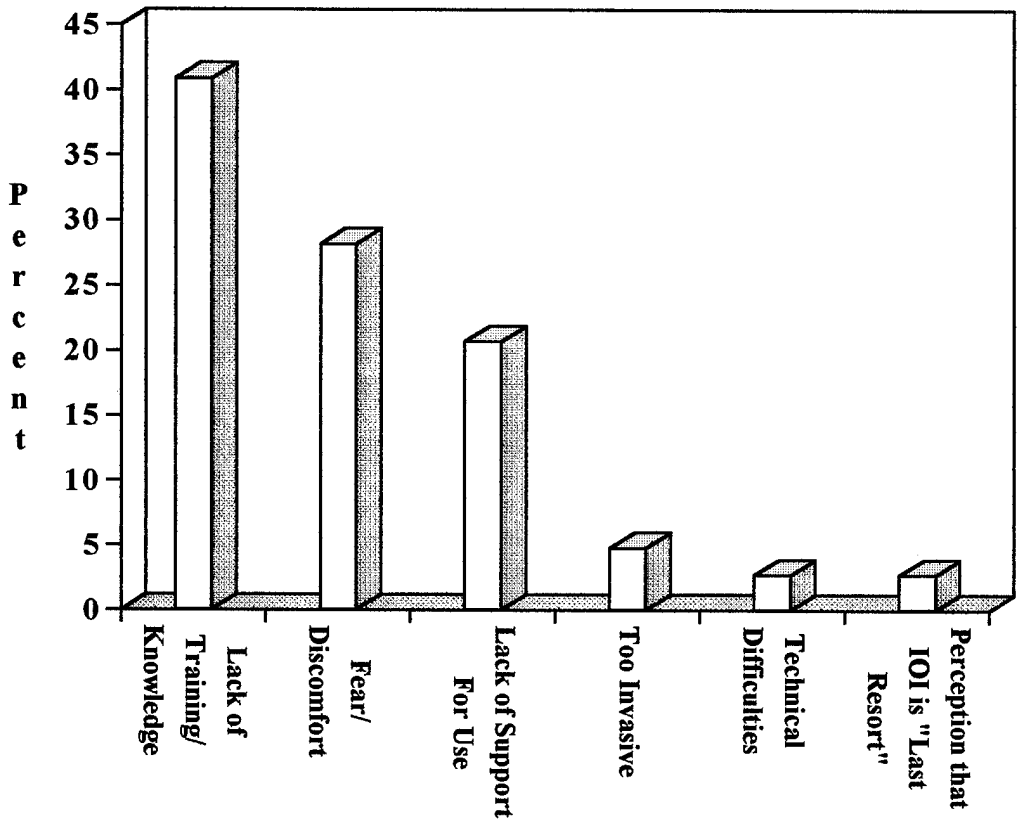


FIGURE 8. Barriers to the Use of the Intraosseous Infusion by Emergency Nurses (Groupings Applied to Respondents' Answers to Open-Ended Questions).

knowledge (20.8%), fear of the procedure or a reluctance to use it (19.2%), failure to think of using the procedure early during the resuscitation (16.6%), unnecessary time used attempting peripheral IV access (9.1%), and a lack of support for use by nurses (4.8%). A small percentage of the respondents, 8.6%, were unsure if the procedure was underutilized.

Many respondents provided anecdotal comments regarding their use of IOI. IOI education and training, attributes of the procedure, technical aspects and complications, institutional policies, and prehospital use emerged as dominant themes. Education and training issues were most frequently reported; many nurses wrote that education in IOI should focus not only on the technical aspects of insertion, but should also provide information to assist the nurse in the decision-making process of when to use IOI. One respondent replied, "IOI insertion was easy, once the decision was made to use it." Others indicated that IOI should be more forcefully advocated as an alternate to IV access, not as a "last resort," and that positive attributes of the procedure should be emphasized.

One respondent lamented the lack of support and encouragement given to nurses who use this "new" skill. Others commented on the need for institutional policies or standards that would cover nursing use of the procedure, suggesting specific IOI inservices and annual certifications. Even in institutions where nurses are not allowed to actually perform the procedure, education and training would give nurses the confidence to suggest the use of IOI and assist with its insertion. Several respondents described having IOI equipment ready was "half the battle," and that much of the anxiety related to

the procedure could be decreased by putting all the equipment needed for IOI together in one place; others cited the importance of using needles specifically designed for IOI.

# Chapter V

## Summary and Recommendations

This chapter presents a summary of the study findings, discusses the strengths and limitations of the study, discusses the implications of the findings for emergency nursing and Utilization Management/Managed Health Care, and presents recommendations for further research.

### Discussion of Findings

The study revealed widespread awareness of IOI among emergency nurses. Although most respondents had not performed the procedure, almost one-half the sample had assisted. Although about one-third of the nurses had not used IOI, most of these had been trained. A small percentage of the sample had no IOI experience or training.

Despite the widespread awareness of the procedure, its use was often not consistent with the recommendations of PALS. Less than one-half of the sample reported time elapsed without intravascular access as a factor in their decision to use IOI. When time was a factor, the decision was most frequently made after five to ten minutes, far in excess of the PALS (Chameides, 1994) recommendation of 90 seconds. The number of unsuccessful IV attempts was a major factor in many nurses' decision to use IOI; the majority reported using IOI after two to three unsuccessful IV attempts, comparable with the PALS recommendations.

IOI use was widespread across respondents according to age and number of years in the healthcare field, although a somewhat lower use was reported by nurses with more than 16 years of healthcare experience, perhaps explained by the relatively recent return

of IOI to clinical practice. Not surprisingly, IOI use increased with the number of annual pediatric resuscitations in which the respondent participated. IOI use was also widespread across the U.S. although somewhat less use was noted in the East South Central states. Study results indicated IOI use was distributed throughout the many types of healthcare facilities with the exception of rural facilities. This finding of a lower use of IOI in rural areas has implications for emergency nurses practicing in such facilities: the less experience with pediatric resuscitations, the higher the necessity of having an alternate method of intravascular access available.

Prior training in IOI was reported by 89.2% of respondents and three quarters of these nurses with training had used the procedure. Although more respondents received instruction in IOI during a PALS course, higher use rates were seen in respondents who received training with a more specialized focus, such as an Inservice. Nurses who had the opportunity to practice IOI skills, whether on a bone or IOI manikin, reported higher subsequent use rates than nurses who reported only didactic learning of the procedure. This suggests that didactic review as well as practice of IOI skills improves the emergency nurse's confidence and ability to perform the procedure. Somes (1990) describes an ED "skills day" that reviews written materials describing when, why, and how IOI should be done, as well as the significance of results obtained when the nurse performs or assists with IOI. This review is followed by a hands-on session with IOI insertion practice on a chicken bone or IOI manikin.

In the survey sample, the presence of a specific IOI protocol made little difference in participation rates. A more probing question would have determined whether any

protocol was in place that recommended a brief trial of IV access attempts before turning to alternate methods. Rhodes (1994) defined a protocol as a uniform way of approaching a problem that can lead to an anticipated optimum outcome for the patient. He proposed using a protocol as "a potentially useful approach to a complex arena fraught with emotionally held opinions, anecdotal descriptions, and judgmental opinions often repeated in the form and manner of a party line" (Rhodes, 1994, p. 638).

The availability of IOI equipment in the workplace was an important factor in subsequent use; IOI use was also reported to be higher in institutions where IOI was recommended or approved. Employer provision of IOI education and training also resulted in higher reported use rates. An institution where IOI is not recommended or approved is unlikely to provide the necessary IOI equipment, supplies, or training, thus underlying the importance of institutional recommendation or approval of the procedure.

The study revealed widespread approval of IOI among emergency nurse respondents for its simplicity and rapid insertion. Many respondents suggested that increased advocacy of IOI as an alternate method of access, and institutional and colleague approval would encourage its use among emergency nurses. Many reported a lack of education and training in the procedure as the greatest barrier to use. Fear, discomfort, and intimidation with IOI were also deterrents. The healthcare institution itself was frequently cited as a barrier to use.

Many respondents indicated their belief that IOI was underutilized during pediatric resuscitation; many of the perceived reasons for its underutilization could be resolved through education and training and an increased awareness among healthcare providers

and institutions of the viability of the procedure as an effective alternate to intravascular access. Thus, the study revealed that barriers to IOI use require an examination of factors both internal and external to the emergency nurse. The study results were comparable to those of Zimmerman et al. (1989) who reported many healthcare providers' unfamiliarity with IOI, despite its resurgence in popularity. In their survey of Aeromedical Evacuation Squadrons, most providers were unaware of the technique and its effectiveness during pediatric resuscitation.

Several themes emerged during analysis of the anecdotal comments provided by many of the respondents. Categories noted were issues related to education and training, attributes of the procedure (both positive and negative), as well as technical aspects and complications, institutional policies, and prehospital use.

## Strengths and Limitations

Several strengths were noted in this study. A new tool (survey) was developed to identify variables affecting the use of IOI; the descriptive design of the survey allowed respondents to report their use of IOI as well as provide their attitudes, opinions, and beliefs regarding the procedure. A response rate of 48.6% was achieved by distributing the survey to a specialized sample of emergency nurses and the survey sample closely approximated the ENA survey sample. However, possible limitations were also noted. Although the qualitative research conducted was well suited for the purpose of description, it was less suitable for establishing cause and effect relationships among the data (Polit & Hungler, 1991). The use of a survey may have limited the respondent's ability to reply or describe in detail their use of IOI. Mailing of surveys did not allow

for clarification of instructions by participants who did not fully understand the questions, leaving the questions open to individual interpretation and possibly influencing the responses. Nurses who had never used IOI or who had intense negative feelings regarding the procedure may have discarded the survey. Some respondents did not answer all of the questions, thus actual frequencies may be greater or lesser than those reported. Also, self-report measures have the potential for deliberate or unconscious distortions (Polit & Hungler, 1991).

According to Bradburn, Rips, and Shevell (1987), surveys require far more complex mental processes than a simple recall of unambiguous, quantitative facts. Respondents may forget details associated with particular events and may even combine similar incidents into a single, generalized memory. Faced with questions regarding the number of times they had assisted with or performed IOI, respondents may have relied on inferences or approximations which operated on fragmented recall. Further, respondents may have interpreted and answered the survey questions in the context of their general knowledge of IOI, their perception of the expectations of the investigator, or the social desirability of their answers.

Two types of errors in the data reporting were possible: one of commission (reporting an act which did not take place) or one of omission (failure to report an act which actually occurred). An error of omission would be less likely due to subjectively vivid memories resulting from an emotional and intense experience such as using IOI during a pediatric resuscitation (Bradburn, Rips, Shevell, 1987).

Other limitations to the study involved asking the respondents to provide the

number of IOI procedures in which they had ever participated, while then asking them to provide information on their current practice. Such an incongruence in the data limited the ability to use meaningful comparative statistics. Future studies using this instrument should adapt the questions to separately reflect the use of IOI in the emergency nurses' current practice as well as IOI use throughout their nursing career. Such data would allow the use of comparative statistics beyond the descriptive nature of this study.

The use of the ENA membership may limit the generalizability of the data to all emergency nurses. Although the ENA is the largest emergency specialty organization for nurses, not all emergency nurses are members. ENA membership may represent older, more experienced nurses, as well as nurses who are more clinically proficient or actively involved in their professional development. Also, ENA members may be more likely to attend national or local conferences, stay current with emergency nursing issues, or base their clinical practice on research findings (Kelly, 1995). Thus, it is likely the study results overrespresent emergency nurses' use of IOI.

## Implications for Emergency Nursing

The study findings present several implications for emergency nursing in the areas of clinical practice, education, management, and research. It is apparent from reviews of the literature that the concepts of this procedure are relevant to emergency nursing regardless of the nurse's level of participation; even if the emergency nurse does not actually perform IOI, he/she can suggest and assist with the procedure. Collaboration of the healthcare team ensures optimal care of the pediatric patient during resuscitation.

The results indicate that the greatest challenge is in education and training. Ready

(1994) describes the necessity of acquiring cognitive as well as psychomotor skills, especially in areas such as the ED with highly complex skills and procedures. These complex skills require a high level of judgment in addition to physical mastery of the skill. Somes (1990) writes that frequent review and practice of a skill or procedure can improve confidence and ability and suggests an annual "skills day" as an excellent education and training method. She describes IOI as a skill well-suited to an ED Inservice presentation.

ED management must explore the need for standardized protocols to provide consistent approaches to training as well as aid in the decision-making process of when to use IOI. A protocol can provide needed organization, especially for those healthcare providers with less experience in pediatric resuscitation. The guidelines outlined in PALS (Chameides, 1994) could easily be incorporated into a pediatric resuscitation protocol. Rhodes (1994), reported that healthcare providers were concerned that protocols may be rigid, unthinking, or oversimplified. However, the author indicated that clinical management protocols can be dynamic, efficient, and cost-effective. When based on research, protocols can be readily incorporated into educational and Continuous Quality Improvement (CQI) activities. A protocol can provide a sound clinical framework for diagnostic and treatment approaches. CQI mechanisms should be used to evaluate the extent to which IOI use affects pediatric resuscitation and patient outcome. Anecdotal comments provided by many of the survey respondents point out the need for a central location of IOI equipment and suggest a separate pediatric "crash cart" for rapid retrieval of pediatric resuscitation equipment.

## Implications for Utilization Management/Managed Health Care

The results of this study are equally applicable to military, as well as civilian emergency nurses. Military emergency nurses provide care in a variety of settings, from the Military Treatment Facility, to zones of conflict, to mass casualty/disaster situations. The care of pediatric patients requiring resuscitation presents challenges to even experienced emergency nurses. Expansion of circulating blood volume is a critical component of pediatric advanced life support in children who have sustained trauma with acute blood loss and it may also be lifesaving in the treatment of non-traumatic shock, such as severe dehydration or sepsis. Intravascular access is vital for fluid and medications administration but may be difficult in the pediatric patient (Chameides, 1994).

Clinical management protocols encompassing intravascular access during pediatric resuscitations can be incorporated into clinical pathways to provide a uniform way of approaching care. Such protocols are useful in organizing care and determining therapeutic priorities. They also provide a rational, systematic process that, once learned, become internalized (Rhodes, 1994). A branch-chain decision tree that proposes specific criteria for intravascular access should include IOI. Each Military Treatment Facility must also provide the necessary IOI equipment and training to all emergency nurses who care for pediatric patients. Utilization Management/Managed Health Care demands the provision of quality patient care in a cost-effective manner. The use of IOI as an alternate method of intravascular access during pediatric resuscitation is a rapid, simple, and effective means of achieving this goal.

## Recommendations for Further Research

Further research is needed to determine if pediatric resuscitations without intravascular access or with delayed access suffer poorer outcomes. Although research has already shown the effectiveness of IOI, an exploration of the most effective methods of disseminating the information is the next step. Similarly, campaigns to present the positive aspects of IOI use are necessary in order to dispel its reputation as a method of "last resort."

Macrina, Macrina, Horvath, Gallaspy and Fine (1996) presented an adaptation of a model originally described by Green and Kreuter (1991). As shown in Figure 9, this model provides the structure for identifying predisposing, enabling, and reinforcing factors that affect the individual's behavior (emergency nurse's use of IOI). The basic assumption of this model, as well as that of Cervero (1985), is that behaviors are influenced by many variables, including but not limited to, knowledge. Predisposing factors include the emergency nurse's attitudes, beliefs and perceptions and can facilitate or hinder motivation for using IOI. Likewise, enabling factors can facilitate or hinder change; the emergency nurse may be willing to use IOI, but may be restricted by a lack of knowledge, training, equipment, or institutional policy. Reinforcing factors are the rewards received; the positive or negative feedback the emergency nurse receives from others following use, or suggestion of use of IOI, can encourage or discourage future behavior. Use of IOI is complex and multidimensional in nature evolving from the interplay between the emergency nurse, the procedure itself, education and training in the procedure, and institutional policies (Green & Kreuter, 1991). As none of these

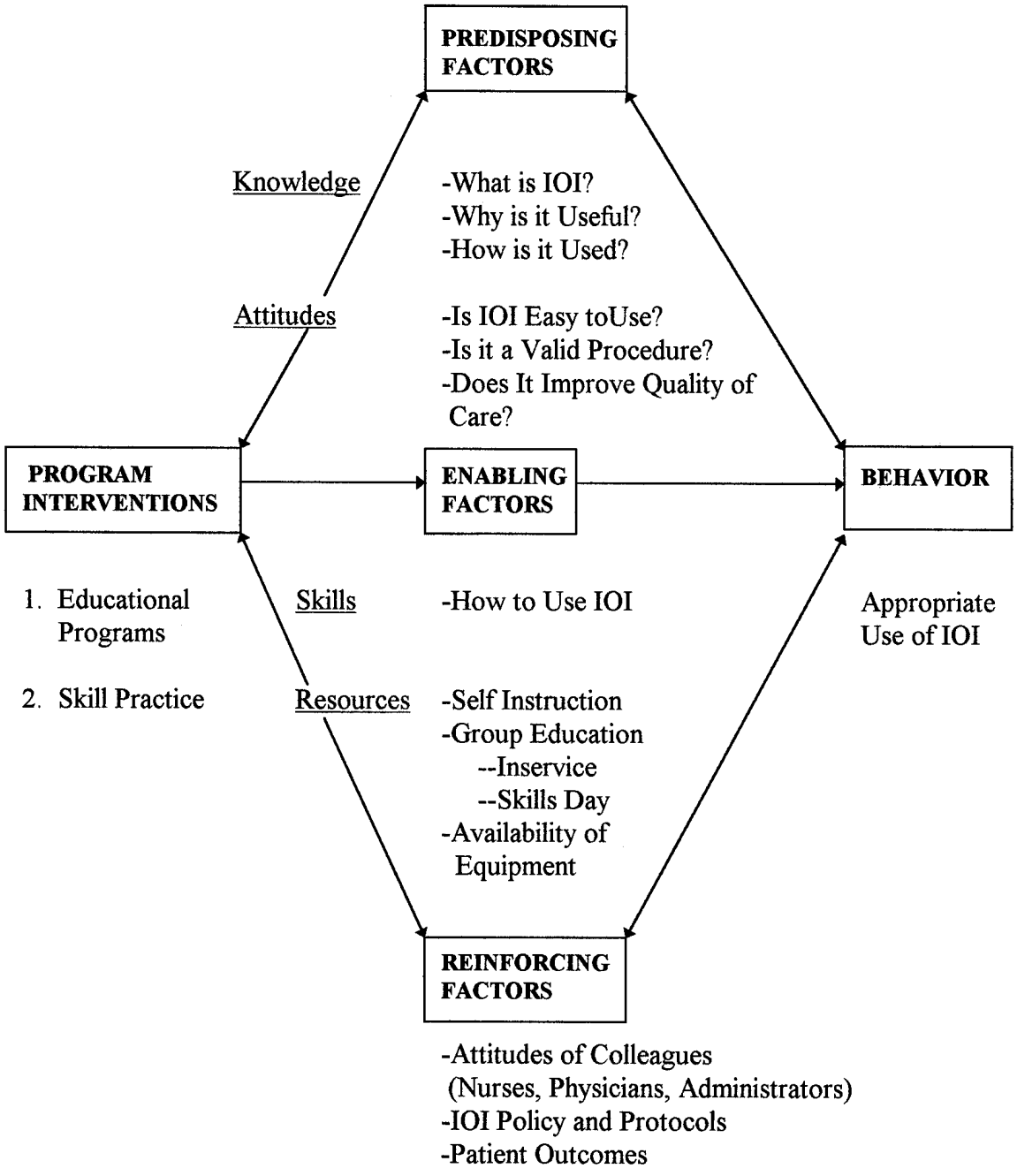


FIGURE 9. Adaptation of PRECEDE-PROCEED model (Macrina et al., 1996) which provides structure for identifying predisposing, enabling, and reinforcing factors which affect emergency nurses' use of the IOI.

variables can be effectively addressed in isolation, efforts to facilitate the use of IOI by emergency nurses must likewise be multidimensional.

## LIST OF REFERENCES


Bradburn, N.M. Rips, L.J., & Shevell, S.K. (1987) Answering autobiographical questions: The impact of memory and inference on surveys. Science, 236(4798), 157-161.

Brunette, D. D., & Fischer, R. (1988). Intravascular access in pediatric cardiac arrest. American Journal of Emergency Medicine, 6(6), 577-579.

Cameron, J. L., Fontanarosa, P. B., & Passalaqua, A. M. (1989). A comparative study of peripheral to central circulation delivery times between intraosseous and intravenous injection using radionuclide technique in normovolemic and hypovolemic canines. Journal of Emergency Medicine, 7, 123-127.

Cervero, R. M. (1985). Continuing professional and behavioral change: A model for research and evaluation. Journal of Continuing Education in Nursing, 16(3), 85-88.

Chameides, L. (Ed.). (1994). Textbook of Pediatric Advanced Life Support, Dallas, TX: American Heart Association.

Dillman, D.A. (1978). Mail and Telephone Surveys: The Total Design Method, New York: John Wiley & Sons.

Drinker, C., Drinker, K., & Lund, C. (1922). The circulation in mammalian bone marrow. American Journal of Physiology, 117(13), 1-92.

Elston, J.T., Jaynes, R.V., Kaump, D.H., & Irwin, W.A. (1947). Intraosseous infusion in infants. American Journal of Clinical Pathology, 17, 143-158.

Evans, R.J., McCabe, M., & Thomas, R. (1994). Intraosseous infusion. British Journal of Hospital Medicine, 51(4), 161-164.

Fuchs, S., LaCovey, D., & Paris, P. (1991). A prehospital model of intraosseous infusion. Annals of Emergency Medicine, 20(4), 371-374.

Glaeser, P. W., Hellmich, T. R., Szewczuga, D., Losek, J. D., & Smith, D. S. (1993). Five year experience in prehospital intraosseous infusion in children and adults. Annals of Emergency Medicine, 22(7), 1119-1124.

Green, L.W., & Kreuter, M.W. (1991). Health Promotion Planning: An Educational and Environmental Approach. (2nd ed.). Mountain View, CA: Mayfield Publishing Company.

Haley, K., & Baker, P. (Eds.). (1993). Provider Manual of the Emergency Nursing Pediatric Course, Emergency Nurses Association.

LIST OF REFERENCES, Continued

Heinild, S., Sondergaard, T., & Tudvad, F. (1947). Bone marrow infusion in childhood. Journal of Pediatrics, 30, 400-412.

Jaimovich, D., & Kecskes, S. (1991). Intraosseous infusion: A rediscovered procedure as an alternative for pediatric vascular access. Indian Journal of Pediatrics, 58(3), 329-334.

Kanouse, D. E., & Jacoby, I. (1988). When does information change practitioners' behavior? International Journal of Technology Assessment in Health Care, 4, 27-33.

Katz, D. S., & Wojtowycz, A. R. (1994). Tibial fracture: A complication of intraosseous infusion. American Journal of Emergency Medicine, 12(2), 258.

Kelly, K. (1995). Critical Care Nurses' Knowledge of Continuous Mixed-Venous Oxygen Saturation Monitoring. Unpublished masters thesis. University of Washington, Seattle.

Losek, J.D., Hennes, H., Glaeser, P., Hendley, G., & Nelson, D.B. (1987). Prehospital care of the pulseless, nonbreathing pediatric patient. American Journal of Emergency Medicine, 5(5), 370-374.

Macrina, D., Macrina, N., Horvath, C., Gallaspy, J., & Fine, P. (1996). An educational intervention to increase use of the Glasgow Coma Scale by emergency department personnel. International Journal of Trauma, 2(1), 7-12.

Manley, L., Haley, K., & Dick, M. (1989). Intraosseous infusion: Rapid vascular access for critically ill or injured infants and children. Journal of Emergency Nursing, 14(92), 63-68.

Neal, C.J., & McKinley, D.F. (1994). Intraosseous infusion in pediatric patients. Journal of the American Osteopathic Association, 94(1), 63-66.

Orlowski, J. P., Porembka, D. T., Gallagher, J. M., Lochrem, J. D., & VanLente, F. (1990). Comparison study of intraosseous, central intravenous, and peripheral intravenous infusions of emergency drugs. American Journal of Diseases in Childhood, 144, 112-117.

Parrish, G. A., Turkewitz, D., & Skiendzielewski, J. J. (1986). Intraosseous infusion in the Emergency Department. American Journal of Emergency Medicine, 4(1), 59-63.

LIST OF REFERENCES, Continued

Polit, D. F., & Hungler, B. P. (1991). Nursing research: Principles and methods (4th ed.). Philadelphia: Lippincott.

Ready, R.W. (1994). Clinical competency testing for emergency nurses. Journal of Emergency Nursing, 20(1), 24-32.

Rieger, A., Berman, J. M., & Striebel, H. W. (1994). Initial resuscitation and vascular access. Journal of International Anesthesiology Clinics, 32(1), 47-77.

Reisman, H. A., & Tainsky, I. A. (1944). The bone marrow as an alternate route for transfusion in children. American Journal of the Diseases of Children, 68, 253-256.

Rhodes M. (1994). Practice management guidelines for trauma care: Presidential address, seventh Scientific Assembly of the Eastern Association for the Surgery of Trauma. Journal of Trauma, 37(4), 635-642.

Rosetti, V., Thompson, B.M., Aprahamian, C., Darin, J.C., & Mateer, J.R. (1984). Difficulty and delay in intravascular access in pediatric arrests. Annals of Emergency Medicine, 13(5), 406.

Rosetti, V., Thompson, B. M., Miller, J., Mateer, J.R., & Aprahamian, C. (1985). Intraosseous infusion: An alternate route of pediatric intravascular access. Annals of Emergency Medicine, 14(9), 885-889.

Salassi-Scotter, M. & Fiser, D. H. (1990). Adoption of intraosseous infusion technique for prehospital pediatric emergency care. Pediatric Emergency Medicine, 6(4), 263-265.

Sawyer, R. W., Bodai, B. I., & Blaisdell, W. (1994). The current status of intraosseous infusion. Journal of the American College of Surgeons, 179, 353-358.

Schoenfeld, P. S., & Baker, M. D. (1993). Management of cardiopulmonary and trauma resuscitation in the pediatric emergency department. Pediatrics, 91(4), 726-729.

Siegler, R. S., Tecklenburg, F. W., & Shealy, R. (1989). Prehospital intraosseous infusion by emergency medical services personnel: A prospective study. Pediatrics, 84(1), 173-177.

LIST OF REFERENCES, Continued

Smith, R. J., Keseg, D. P., Manley, L. K., & Standeford, T. (1988). Intraosseous infusions by prehospital personnel in critically ill pediatric patients. Annals of Emergency Medicine, 17(5), 491-494.

Somes, J. (1990). Skill Day: A method of reviewing and verifying ED skills for nurses. Journal of Emergency Nursing, 16(2), 111-116.

Tocantins, L. M. (1940). Rapid absorption of substances injected into the bone marrow. Proceedings of the Society of Experimental and Biological Medicine, 45, 292-295.

Tsai, A., & Kallsen, G. (1987). The epidemiology of pediatric pre-hospital care. Annals of Emergency Medicine, 16(3), 284-292.

Wagner, M. B., & McCabe, J. B. (1988). A comparison of four techniques to establish intraosseous infusion. Pediatric Emergency Care, 4(2), 87-91.

Wheeler, C.A. (1988). Pediatric intraosseous infusion: An old technique in modern health care technology. Journal of Intravenous Nursing, 12(6), 371-376.

Wright, R., Reynolds, S. L., & Nachtsheim, B. (1994). Compartment syndrome secondary to prolonged intraosseous infusion. Pediatric Emergency Care, 10(3), 157-158.

Zimmerman, J. J., Coyne, M., & Logsdon, M. (1989). Implementation of intraosseous infusion technique in aeromedical transport programs. Journal of Trauma, 29(5), 687-684.

# Appendix A

## Use of the Intraosseous Infusion Technique Survey

**Instructions:** Please complete the following questions by circling the appropriate response(s) and/or filling in the appropriate blanks. Return the survey in the pre-paid and addressed envelope provided.

**Healthcare Provider Information**

1. Your Status:

    1. Staff Nurse
    2. Nurse Practitioner
    3. Clinical Nurse Specialist
    4. Nurse Manager/Administrator
    5. Flight Nurse
    6. Other. . . (Please specify) _____

2. Your area of practice:

    1. Emergency Department
    2. Aeromedical Evacuation Squadron
    3. Mobile Intensive Care Unit
    4. Other. . . (Please specify) _____

3. If your area of practice is the **Emergency Department**, specify type of facility:

    1. Trauma Center, Level:_____
    2. University/Teaching Hospital
    3. Community Hospital
    4. Children's Hospital
    5. Military Facility
    6. Other... (Please specify) _____

4. Name of state/country in which you practice: _____

5. Your specialty: _____

6. Number of years you have worked in the healthcare field: _____ Years

7. Your present age:_____Years

8. Your gender:

    1. Male
    2. Female

9. How many resuscitations of children under 6 years of age do you participate in per year?

    1. None
    2. Less than 5
    3. 6-10
    4. 11-15
    5. Greater than 16

**Use of the Intraosseous Infusion Technique**

10. Have you ever performed an intraosseous insertion?

    1. Yes (If yes, number of times:_____)
    2. No

11. Have you ever assisted with an intraosseous insertion?

    1. Yes (If yes, number of times:_____)
    2. No

**If you answered NO to questions 10 and 11, please go on to question 17**
**If you answered YES to either question 10 or 11, please continue**

12. When do you use or assist with intraosseous insertion? (Circle all that apply)

    1. After attempt(s) at peripheral intravenous (IV) access are unsuccessful (Specify number of attempts:____)
    2. After attempts at venous cutdown are unsuccessful
    3. After attempts at central venous access are unsuccessful
    4. After a specific amount of time has elapsed without successful venous access (Specify amount of time:_____minutes)
    5. Other. . . (Please specify) _____

13. What substances have you infused through an intraosseous infusion? (Circle all that apply)

    1. Intravenous Fluids
    2. Blood
    3. Medications
    4. Other. . . (Please specify) _____

14. Under what circumstances have you used an intraosseous infusion? (Circle all that apply)

    1. Cardiac Arrest
    2. Respiratory Arrest
    3. Shock
    4. Burns
    5. Drowning/Near Drowning
    6. Other. . . (Please specify) _____

15. Under what conditions have you inserted/assisted with an intraosseous infusion insertion? (Circle all that apply)

    1. In the Emergency Department
    2. In "the field"
    3. During patient transport
    4. Other. . . (Please specify) _____

16. What is the age range of the patients in which you have inserted/assisted with an intraosseous infusion insertion (Years/Months)? _____

**Training**

17. Where/how did you receive training in the intraosseous infusion technique? (Circle all that apply)

    1. Nursing School
    2. Basic Trauma Life Support (BTLS)
    3. Advanced Trauma Life Support (ATLS)
    4. Pediatric Advanced Life Support (PALS)
    5. Trauma Nurse Core Curriculum (TNCC)
    6. Emergency Nurse Pediatric Course (ENPC)
    7. Inservice
    8. None
    9. Other. . . (Please specify) _____

18. What did your training in the intraosseous infusion technique include? (Circle all that apply)

    1. Lecture
    2. Film/Video/Slides
    3. Book/Handout
    4. Hands-on practice with:
       A. Intraosseous Manikin B. Chicken/Turkey Leg Bone
    5. Length of Training: _____Hours
    6. Other. . . (Please specify)_____
    7. Not Applicable-Not Trained in the Intraosseous Infusion Technique

**Institutional Policy**

19. Does your work area have an intraosseous infusion protocol, algorithm, or operating instruction?

    1. Yes
    2. No
    3. Don't Know

20. Are equipment/supplies for intraosseous insertion (i.e. intraosseous or bone marrow needles) available to you in your work area?

    1. Yes
    2. No
    3. Don't Know

21. Does your place of employment recommend the intraosseous infusion for pediatric resuscitation?

    1. Yes
    2. No
    3. Don't Know

22. Does your place of employment provide training in the intraosseous infusion technique?

    1. Yes
    2. No
    3. Don't Know

**Personal Experiences**

23. Please relate your personal experiences with, and opinions of, the intraosseous infusion technique:

    1. How effective/realistic was the intraosseous training you received?

    2. Rate your perception of the level of difficulty of an actual intraosseous insertion (on a scale of 1 to 10, with 1=very simple, and 10=very difficult):

    3. Your success/failure rate (success=fluid flows freely) with intraosseous insertion:

    4. Have you had any difficulties/complications with intraosseous insertion?

    5. What do you **like** about the intraosseous infusion technique?

    6. What do you **dislike** about the intraosseous infusion technique?

    7. What factors or circumstances do you think **encourage** other emergency nurses to use the intraosseous route?

    8. What factors or circumstances do you believe are **barriers** to (or **discourage**) the use of the intraosseous route by other emergency nurses?

    9. Do you believe intraosseous infusions are underutilized in pediatric resuscitations? Why or why not?

24. If you have **never** performed or assisted with an intraosseous insertion, please explain: (Circle all that apply)

    1. I have never heard of the intraosseous infusion technique before
    2. I am not trained in the intraosseous infusion technique
    3. The intraosseous infusion technique is not in my scope of practice
    4. I do not take care of pediatric patients
    5. I have a personal dislike of the intraosseous infusion technique
    6. I have not had the opportunity to use the intraosseous infusion technique
    7. My institution does not allow the intraosseous infusion technique to be performed
    8. Other. . . (Please specify) _____

Is there anything else you would like to tell me regarding your experiences with the intraosseous infusion technique? If so, please use this space for that purpose.

Also, any comments you wish to make that you think may help me in my effort to identify factors affecting the use of the intraosseous infusion technique will be appreciated.

Thank you for taking the time to complete this survey. Your contribution to this study is greatly appreciated. If you have any additional comments or concerns, please provide in the space below. If you would like a summary of the study results, please print your name and address on the enclosed index card (NOT on the survey itself) and return it with your completed survey. The index card will be separated from the survey immediately upon receipt to ensure complete anonymity. You may also mail the index card separate from the completed survey, if you wish.

# Appendix B

## Cover Letter for Use of the Intraosseous Infusion Technique Survey

UNIVERSITY OF WASHINGTON
School of Nursing
Department of Biobehavioral Nursing and Health Systems

Variables Affecting the Use of the
Intraosseous Infusion During Pediatric Resuscitation

Primary Investigator:
Sharon L. Hale, RN, CEN, CFRN
Major, United States Air Force, Nurse Corps
Graduate Student, Department of Biobehavioral Nursing and Health Systems, Box 357266
University of Washington School of Nursing, Seattle, WA, 98195-7266

Faculty Advisor/Thesis Committee Chairperson:
Eleanor Bond, Ph.D., RN
Associate Professor
Department of Biobehavioral Nursing and Health Systems

Dear Emergency Nurses Association Member:

I am conducting a study to **identify variables affecting the use of the intraosseous infusion during pediatric resuscitation.** This study partially fulfills the requirements for a master's degree in critical care nursing. Your name was selected from a random sample of Emergency Nurses Association (ENA) members; name/address labels were obtained from the ENA following approval of the survey by the Research Committee. Would you please assist me by completing the attached survey?

Use of the intraosseous infusion route involves placing a needle into the marrow cavity of a long bone, usually the anterior surface of the proximal tibia. Though use of this route has been documented since the 1920s, only recently has a renewed interest in the intraosseous infusion as an alternate method of pediatric intravascular access occurred. Successful use of the intraosseous infusion has been reported in both the hospital and pre-hospital environment, primarily in children under 6 years of age.

**Your opinions of, and experiences with, the intraosseous infusion are very important and are needed to obtain an accurate portrayal of how this route is used in clinical practice by emergency nurses, and what factors affect its use. Please complete the survey even if you have never used or assisted with the intraosseous infusion technique.**

Participation in the study is completely voluntary; you are free not to answer any of the questions. All replies are anonymous so I hope you will feel comfortable in giving your honest opinions. The data obtained from completed surveys will be reported in group form only, will be published as a master's thesis, and will be kept indefinitely. If you have comments or concerns about any question, just write them in the margin or on the back of the page. A postage-paid return envelope has been provided for your convenience. Please complete the survey (it should take only about 10-15 minutes of your time) and return it by **25 October 1995.** Your informed consent will be implied by the return of the survey

Thank you for your time and interest. If you would like a summary of the study results, please print your name and address on the enclosed index card, fold it, and return it with your survey. Upon receipt, the index card will be separated from your survey by a disinterested volunteer to ensure anonymity.

Sharon L. Hale, RN, CEN, CFRN

Appendix C

Letter for Pilot Study Participants

To: Reviewers of Intraosseous Infusion Survey (Pilot Study)

From: Sharon L. Hale, RN, University of Washington Graduate Student

Date:

I am conducting a pilot study in order to pre-test a newly developed survey attempting to identify variables affecting the use of the intraosseous infusion during pediatric resuscitation. Development of this survey was guided by a theoretical framework linking use of the intraosseous infusion (behavior) with 4 independent variables: the emergency nurse, the intraosseous procedure itself, the emergency nurse's education and training in the intraosseous infusion procedure, and the environment (work area) in which the emergency nurse practices.

The survey is on 5 pages and includes a cover letter. Please **evaluate the survey** in terms of whether it will accomplish the study objective. Specifically:

- Is the survey too short? Too long?
- Are all the words understandable?
- Do each of the closed-ended (multiple answer) questions have an answer that applies to you?
- Does the survey create a positive impression?
- Does any part of the survey suggest bias on the part of the researcher?
- Are there other questions that you believe should be included in the survey?
- Any questions which should be eliminated?

Please review the survey, answer the survey questions, and write any comments below the questions or in the margin. . Your comments will remain anonymous.

Please return by_____ to _____

Sharon L. Hale, RN, CEN, CFRN
Graduate Student, University of Washington School of Nursing
Department of Biobehavioral Nursing and Health Systems

Appendix D

Follow-Up Postcard

Dear Emergency Nurses Association Member:

Last week a survey seeking your experiences with, and opinions of, the intraosseous infusion during pediatric resuscitation was mailed to you. Your name was drawn from a random sample of Emergency Nurses Association (ENA) members.

If you have already completed and returned the survey, please accept my sincere thanks. If not, please do so today. Because the survey has been sent to a small, but representative, sample of ENA members it is extremely important that yours be included in the study if the results are to accurately reflect the experiences and opinions of emergency nurses.

If by some chance you did not receive the survey, or it has been misplaced, please call me collect at 206-589-0834 and I will get another one in the mail to you.

Sincerely,

Sharon L. Hale, RN, CEN, CFRN
Graduate Student, University of Washington
School of Nursing